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EARTHQUAKE FORECASTS[1]

INTRODUCTION

THERE was a time when the weather belonged to the gods. Storms and drought were inflicted on man in punishment or for vengeance, man strove to avert them by sacrifice or prayer, and the priest was his intercessor. Now the weather belongs to nature, and the priestly robe has fallen on the Weather Bureau. Man's new agent, however, is not an intercessor; he does nothing to placate; he makes no attempt to control the course of nature; but inspired by science he foretells the coming changes so that his lay client may take warning and be prepared. The crops are harvested before the rain, the herds escape from the lowland before the flood, the ships reach harbor before the gale; and man chants a hymn of praise to science.

There was a time when the earthquake was equally enveloped in mystery, and was forecast in the enigmatic phrases of the astrologer and oracle; and now that it too has passed from the shadow of the occult to the light of knowledge, the people of the civilized earth—the lay clients of the seismologist—would be glad to know whether the time has yet come for a scientific forecast of the impending tremor. The outlook for earthquake forecasting is my theme to-day.

As you are aware, I am not a seismologist. My point of view is that of the geologist and general geographer. I speak as

[1] Presidential address to the American Association of Geographers, read at Baltimore, Md., January 1, 1909.

a layman, and present impressions acquired chiefly during somewhat amateurish work on the physical history of the San Francisco earthquake. That event was so far unforeseen that no seismologists were at hand, and the duty of investigation fell, in the emergency, on a volunteer corps of geologists and astronomers. For me it proved a fascinating subject, and interest did not cease with the completion of the special task.

But while this much is offered by way of explanation, and to prevent misunderstanding, you are not to infer that an apology is made because I tresspass on fields to which I have no title, for I am an advocate of the principle of scientific trespass. The specialist who forever stays at home and digs and delves within his private enclosure has all the advantages of intensive cultivation—except one; and the thing he misses is cross-fertilization. Trespass is one of the ways of securing cross-fertilization for his own crops, and of carrying cross-fertilization to the paddock he invades. Hypotheses, the trial theories which compete for development into final theories, spring by the principle of analogy from earlier and successful theories, and the broader the investigator's knowledge of explanatory science the greater his opportunity to discover hypotheses that may be applied to his own problems. Progress is ever through the interaction of the sciences one on another; and scientific trespass is one of the profitable modes of interaction. The trespasser brings with him a mental attitude and a mental equipment which are new to the subject, and whether or no the idea he contributes eventually "makes good," its contribution creates a new category for observation and opens a new avenue of inquiry. And he carries back with him the pollen of new ideas.

Next to verity, the factors which give value to an earthquake prediction are definiteness as to time and place. If the geologist Whitney, in warning San Franciscans forty years ago that their city would suffer by earthquake, had been able to specify the year 1906, and to convince them that he had warrant for his prophecy, the shock, when it came, would have been a phenomenon only and not a catastrophe. If any of those mysterious oracles who were said to have predicted earth convulsions in 1906 had named San Francisco, and told their reasons, the course of history might have been different.

PLACE

Let us consider first the possibility of scientific forecast as to place, and in so doing let us assume the point of view of the resident. The factor in which he is personally interested is the factor of danger—danger to life, danger to property, danger to the present generation. Except as a matter of curiosity, he is not concerned with faint tremors and minor shocks, nor with violent shocks likely to come after centuries of immunity. It will be convenient, at least for this day and hour, to embody our point of view in a concise term, and the adjective *malloseismic* will be used to designate localities likely to be visited several times in a century by earthquakes of destructive violence.

Experience.—The most important of all bases for the indication of earthquake localities is experience. Where tremors have been frequent in the past, there they are to be expected in the future. This premise hardly requires discussion, for it is founded on our confidence in the continuity of the great processes concerned in the evolution of the earth. We recognize indeed that continuity may fail in any particular case, but we always assume it as far more probable than discontinuity.

Other bases for forecast are connected with our conceptions as to the origin of earthquakes. The theory of earthquakes now generally accepted ascribes them to the sudden breaking or slipping of rocks previously in a condition of shearing strain. Exception should probably be made of some of the shocks accompanying volcanic eruptions, but volcanic shocks constitute a class by themselves to which it is not important to extend the present discussion. In non-volcanic, or ordinary, examples it is believed that the strains arise in connection with those tectonic or diastrophic changes which are exhibited superficially in the deformation of the surface, and that their accumulation is gradual. Fracture occurs when and where the internal stress exceeds the strength of the rock, and a fault results. Slipping takes place when the stress along the plane of a preexistent fault exceeds the force of adhesion. In either case it is the instantaneous character of the separation which occasions the jar.

The earthquake being thus a concomitant of tectonic change, its regions of frequency should be found in areas of diastrophic activity, and its occurrence should be rare and sporadic in areas of diastrophic sluggishness. This corollary is so well recognized that seismic activity is commonly regarded as the specific criterion of relatively rapid crustal change. Other criteria of such change are physiographic and geologic, and these may be applied in regions whose earthquake history is unknown. They may also be used, in the absence of seismic records, to give approximate indication of malloseismic localities.

Bold and High Ranges.—It was pointed out by Powell that, because erosion is greatly stimulated by altitude and high declivity, lofty mountains must be regarded as young; and under the principle of continuity young mountains created by uplift are presumably still growing. They are, therefore, phenomena of diastrophic activity and presumably belong to malloseismic districts. The conspicuous example is Mt. St. Elias, which rises boldly 20,000 feet from its base, which was shown by Russell to have continued its growth during the life of the existing marine fauna, and which recently has been signalized by earthquakes of the first class.

Fault Scarps.—Along the bases of block mountains the lines of their limiting faults are sometimes marked by fresh scarps demonstrating recent increase of uplift. In the Great Basin these scarps traverse the alluvium of the piedmont slopes, a surface of such simple type that their presence or absence can be observed with confidence. Their absence suggests diastrophic inactivity or sluggishness, for their effacement is a time-consuming process. Their presence suggests diastrophic activity, and the suggestion is strengthened when their relation to phenomena of weathering and erosion is such as to show that they were produced by a series of recent uplifts instead of one only.

Rifts.—A third physiographic criterion is illustrated in California and was brought to general attention by the San Francisco earthquake. The slip causing that shock occurred on the plane of a fault which outcrops at the surface and has been traced for hundreds of miles. The attitude of the plane is vertical, but the displacement along it was horizontal; and there is reason to think that earlier movements on the same plane were horizontal also, for the fault does not separate a ridge of uplift from a valley of depression but traverses both valleys and mountains. At all points it is included within a belt of peculiar topographic habit, which the investigating geologists have designated as "the rift." Within this belt, which ranges in width from a fraction of a mile

to several miles, are numerous ridges and troughs, long or short, level or inclined, and approximately parallel to the trend of the belt. Each of these represents a dislocated tectonic block, and the dislocation is of so recent date that the disturbed drainage has made little progress toward the restoration of normal conditions. Lakelets are numerous, and streams wander irregularly. Without delaying to attempt a fuller and more adequate description, which may be found in the report of the California Commission,[2] I content myself with an assurance to physiographers that the topographic expression of the rift belt is distinctive, so that it can readily be recognized in other localities by those who have made its personal acquaintance in the field. Other belts of the same character have already been found in California[3] and their discovery elsewhere may confidently be expected.

Rift topography appears to be the surface expression of a species of repetitive horizontal faulting, just as the fault scarp is the surface expression of vertical faulting, and the two types, which with present knowledge are apparently distinct, will doubtless eventually be found to intergrade. The features of the San Andreas rift—the one associated with the San Francisco earthquake—were neither created nor greatly modified at the time of that shock, but such modifications as were made were of such character as to accentuate and perpetuate the peculiarities of the belt. The belt itself would be the natural result of a long series of such events, succeeding one another with such rapidity as to dominate minor aqueous agencies in the modeling of the surface. These considerations, together with the fact that earthquakes are known to have repeatedly originated in the rift belts of California, serve to establish the rift topography as a criterion for the recognition of malloseismic districts.

Geologic Formation.—Fault scarps and rift belts serve to indicate some of the foci of past and future earthquakes. Other foci lie wholly within the earth's crust. Whether the rupture occurs above or below, its jar is propagated through the crust in all directions and affects a large area of the surface. Within this area the intensity of the shock varies primarily with distance from the origin, but it varies also with the character of the geologic formation at the point of emergence. The variation with formation has less range than the variation with distance, but is not less important to the resident and the sojourner, the architect and the engineer—that is to say, it is equally important in forecasting areas of dangerous energy. The portion of San Francisco most intensely racked by the shock of 1906 stood farther from the fault line than the portion least affected, but it stood on less coherent soil. Wood has carefully mapped the distribution of intensity in the San Francisco peninsula, as evidenced by the injury to

[2] California earthquake of April 18, 1906; report of the State Earthquake Investigation Commission; published by the Carnegie Institution, Washington, 1908, pp. 25–52.

[3] The only rift belt beside the San Andreas which has yet been traced for any distance is one which follows in a general way the western base of the Berkeley hills. In the vicinity of Oakland its position is indicated by a trough among the lower hills two or three miles back from the piedmont plain. At Haywards it coincides with the western base of the hills, and at Irvington, with the western base of a projecting spur. In Berkeley also its line follows the base of the hills, but a little northward it climbs to the summit of the first ridge. The principal fault occasioning the earthquake of 1868 was in this rift belt, running from Haywards southward, and it is probable that some of the earlier recorded earthquakes were associated with the same belt. The fault of 1868 is described, and the rift belt is mentioned, in the "Report of the California Earthquake Commission," Vol. I., Part II., pp. 434–5 and 447.

buildings, and shown its close correlation with the distribution of underlying material;[4] and similar, though less detailed, correlations have been made in other regions. On the theoretic side the subject is almost untouched, and there is great need of experimentation, but the empiric results already available have much practical value and enable the geologist and engineer to distinguish broadly, within the limits of a malloseismic district, the tracts more likely, and the tracts less likely, to be affected disastrously by the passing earthquake wave.

On the whole that factor of earthquake forecast which consists in the indication of locality is in a satisfactory condition. In long inhabited regions experience designates certain districts as malloseismic. Newly settled regions may be classified, provisionally and less perfectly, by the data of physiography. And malloseismic districts will eventually be subdivided with confidence by means of geologic criteria.

TIME

Turning now to the time factor in forecasting, and retaining the point of view which emphasizes the element of danger, let us inquire what methods are available for the prediction of the time of occurrence of a destructive earthquake at a given locality or in a given district. Rational attempts to solve this problem have been connected (1) with the idea of rhythm, (2) with that of alternation, (3) with that of the trigger or starter, and (4) with that of the prelude; and each of these lines of approach is worthy of examination.

Rhythm.—Because we are surrounded by and immersed in the rhythms of art and nature, and because the earthquake is a recurrent phenomenon, it is easy to infer that the interval between the last shock and the next will be similar to that between the last and its predecessor. Reasoning of this general tenor probably underlies the greater number of lay forecasts, and is in particular responsible for the wide-spread popular belief that a place recently devastated is *ipso facto* immune for several decades, or at least for several years. A similar belief prevalent among men of science has a slightly different origin, but is even more strongly held; and there is little exaggeration in saying that our guild recognize it is a duty, when the terror-stricken inhabitants of a racked and ruined city seek safety in the open spaces, to assure them that the danger is past and urge them to return to their homes. Now, it is not at all true that either the great shocks or the small shocks affecting a particular locality, or affecting a district, or affecting the earth as a whole, are separated one from another by regular or approximately regular intervals; and it is not at all true that immediate danger is past when a great shock has wrought its havoc; and yet I am prone to believe that the rhythmic principle does hold place in the mechanics of earthquakes. On that point something further will be said, but I shall first invite your attention to the general phenomena of earthquake sequence, selecting examples from the American record because we are most interested in the phenomena of our own territory.

The United States has one well-known malloseismic district, a district including central and southern California, with areas in Mexico and the Pacific Ocean, and possibly extending northward. Alaska also contains a district, and there may be a third in Utah. Since the beginning of the last century, Alaska has experienced at least nine shocks of destructive rank; but the record is fragmentary and may

[4] "Report of the California Earthquake Commission," Vol. I., Part II., pp. 220–45, and atlas, maps 17–19.

omit more than it includes. For the California district eleven are listed, within the same period, the record being somewhat vague, and possibly incomplete, for the first half of the century. To these we may tentatively add the Oregon or Klamath earthquake of 1867 and the Sonora and Arizona earthquake of 1887, raising the number to thirteen. In other parts of the United States were the New Madrid (1811–12), the Charleston (1886), and a relatively weak but probably destructive shock in the New Madrid region in 1865.

The average interval between the individuals of the California series was nine years, and the separate intervals, in order, were: 12, 24, 3, 18, 8, 2, 1, 4, 15, 5, 6 and 8 years. As the centers of disturbance were scattered through the whole district and the areas of dangerous violence were of moderate dimensions, the danger record for any single locality was smaller, and the intervals correspondingly larger. In San Francisco, for instance, the last five destructive shocks have been separated by intervals of 26, 3, 30 and 8 years.

While it is manifest at once that neither of these sequences constitutes a rhythm, it is quite conceivable that they represent in some way a system of rhythms. They might, for example, be composed of several independent rhythms, each beating with its own period; or they might contain imperfectly recorded rhythms, each requiring for its interpretation some of the less violent shocks not included in the destructive class. And if it were possible to group the shocks according to place of origin, it might be found that each earthquake center has its orderly law of sequence. But while the existence of such a systematic arrangement seems within the range of possibility, I regard it as altogether outside the field of probability; and I feel sure that any attempt to discriminate rhythmic series on numerical grounds, without any other basis for classification, would prove unprofitable.

The single element of order which unquestionably belongs to the sequence of quakings is implied by the term after-shock. Every great shock is followed by a train of minor shocks, the length of the train being roughly proportional to the magnitude of the initial shock, and the average strength and frequency of the shocks diminishing with the lapse of time. Usually also the great shock is preceded by faint tremors, or by a few small shocks. The prelude, the great shock and the train of after-shocks, together constitute a typical seismic event, and if their sequence could be absolutely depended on, the terror of the great shock might rationally be palliated by the thought that the worst is over. But unfortunately there are exceptions, and the character of the exceptions is not reassuring. Occasionally the prelude includes a shock of great power, and occasionally the train of after-shocks, instead of being wholly subordinate in intensity, includes one or more major shocks, rivaling the initial shock in violence. Of the twenty-five American examples fourteen were normal and two abnormal, the others remaining unclassified because too little is known of them. It is possibly significant that the two abnormal earthquakes were of exceptional power, the New Madrid heading the list for the United States, and the Yakutat, of Alaska, being of the same order of magnitude. The New Madrid event began with a shock of great violence at 2 o'clock on the morning of December 16, 1811, and this was followed by a long series of vigorous after-shocks, among which eight were noted as of special strength and three were reported as equalling or exceeding the initial shock. Of the last-mentioned, one followed the initial shock after an interval of five hours, and

the others severally after 38 and 53 days.[5] The Yakutat series began with a strong shock September 3, 1899, "and there were shocks at intervals until September 10, when, at 9:20 A.M., they began to be alarming. There were fifty-two shocks, culminating in one of great violence at 3 P.M. . . . There was another violent earthquake September 15 and other shocks until September 20."[6]

In view of these facts the promptings of terror when a great shock comes may well be seconded by the admonitions of wisdom, for even though it be probable that the worst is over, a substantial possibility remains that the worst is still to come. American experience suggests that as often as one time in eight a powerful shock, instead of being the climax of the earthquake, may be only the forerunner of the climax; and when life and limb are at stake the odds of seven to one in favor of safety form but a slender basis for mental serenity.

Turning now from the statistics of sequence to the question of underlying causes, I wish to present a conception of earthquake mechanism which has developed gradually during the study of California phenomena. The block movements associated with earthquakes in California are dominantly horizontal, and the fault planes along which the blocks slide are vertical. For this reason my mental picture of the system of faults (habitually drawn with two dimensions only) is a map instead of a section on a vertical plane. Imagine a large tract of the earth's crust superficially divided by faults into acute-angled blocks, which have a prevailing trend in one direction. In composition the blocks are heterogeneous, including stratified, metamorphic and igneous rocks, with complicated structure. The fault surfaces are not mathematically plane, but gently undulate, so that movement among the blocks involves more or less distortion of the blocks themselves. Imagine also that the tract is subject to external horizontal force of such nature as to induce internal shearing strains and the associated shearing stresses; and that the application of external force is continuous, making the internal stress cumulative. The internal stress is not uniformly distributed, because the more plastic rocks relieve the strain by flowage. When the stress along some part of a fault surface becomes greater than the adhesive force a slip occurs. When the stress within an elastic rock becomes greater than the shearing strength fracture takes place. In either case there is an instantaneous redistribution of stress. Relief of stress in the rock adjacent to the rupture is accompanied by increase of stress about the edges of the surface of parting, with the result that the area of the parting grows; and the growth is continued until regions of small stress are reached. The magnitude of the resulting earthquake depends chiefly on the quality of energy released by the relief of accumulated strain and stress.

If the quantities are large there are important after-effects. The discharge of strain causes a new arrangement of strains and stresses through a large tract; this leads to flowage and the local concentration of stress, especially in the more elastic rock; and this in turn causes fractures, of which the surface manifestations are after-shocks.

When finally equilibrium is restored, and the train of after-shocks is complete, the system of stresses, not only in the immediate neighborhood of the fault, but throughout an extensive tract, is mater-

[5] MS. of report on New Madrid earthquake by M. L. Fuller.

[6] "Recent Changes of Level in the Yakutat Bay Region," by R. S. Tarr and Lawrence Martin, *Bulletin Geol. Soc. Amer.*, Vol. XVII., p. 31.

ially different from what it was before the earthquake. In places, and especially near the fault, the general stress is less; in other places it is greater. The region of maximum stress is ordinarily shifted, so that when stresses imposed by external force again overtax the resistance, the new point of yielding is at some distance from the last.

In view of the complexity of the conditions and the intricacy of the interaction among strains, it is not to be supposed that the status at any one epoch will ever be exactly repeated. Nevertheless, its main features may recur, and whenever they do a cycle will have been completed. Such a cycle, however, would be indefinitely long, and would be too difficult of discovery to be available for purposes of forecast.

It is conceivable also that in some limited portions of the general district the local conditions may give rise to repetitive collapses somewhat independent of the general progress of events. In such case the successive earthquakes would originate in the same place and their systematic character could be recognized through that fact.

There is a class of natural and artificial rhythms in which energy gradually passes into the potential form as internal stress and strain and is thus stored until a resistance of fixed amount is overcome, when a catastrophic discharge of energy takes place. The supply of energy being continuous and uniform, the discharges recur with regular intervals. The frictional machine for generating electric sparks in the laboratory is the type; other examples are the geyser, water gurgling from a bottle, and the alternate adhesion and release of the violin bow in contact with the string. The earthquake is a repetitive catastrophe belonging to the same mechanical group, and if its mechanism were as simple as that of the electric machine its rhythm would be as perfect. If the stresses of an earthquake district affected only homogeneous rock and were always relieved by slipping on the same fault plane, the cycle of events would be regular; but with complexity of structure and multiplicity of alternative points of collapse, all superficial indication of rhythm is lost. If rhythmic order shall ever be found in the apparent confusion, it will be through an analysis which takes account of the points of origin of all important shocks.

Alternation.—The principle of alternation in the occurrence of earthquakes has already been touched. When a large amount of stored energy has been discharged in the production of a great earthquake and its after-shocks, it would seem theoretically that the next great seismic event in the same seismic district was more likely to occur at some other place, and that successive great events would be distributed with a sort of alternation through the district. This hypothesis I used twenty-five years ago, in predicting that the next slip on the fault at the base of the Wasatch range, instead of occurring in the locality of the last previous slip, would take place at a different point;[7] and it has been more recently applied by Omori, Hayes and Lawson in forecasting earthquakes on the western coast of the two Americas. These geographers agree in regarding the entire coast either as a single seismic district or as a portion of a greater district in which there is interdependence of parts. Omori pointed out that in the period of six years from 1899 to 1905 there were extensive disturbances in Alaska, Mexico, Central America, Colombia and Ecuador; stated that the gap thus left between Alaska and Mexico had led him to anticipate an early

[7] Monograph I., U. S. Geological Survey, p. 362.

rupture in that tract of coast; and suggested, after his first anticipation had been realized by the San Francisco earthquake, that the next disturbance might be south of the equator—where the Valparaiso earthquake soon afterward occurred.[8] Hayes, after the San Francisco and Valparaiso earthquakes, suggested Mexico as a probable locality for the next rupture; and after the earthquake which devastated the state of Guerrero in southern Mexico, made a similar suggestion as to Colombia.[9]

[8] In an interview published by the San Francisco *Bulletin* of June 13, 1906, F. Omori says: "Between 1899 and January 1 of this year (1906) there have been several extensive earthquakes along the coast of Alaska, Mexico, Central America, Colombia and Ecuador. These disturbances are not to be regarded as separate or unconnected phenomena, but were the result of great stress which was taking place all along the west coast of North and South America. The Pacific slope of the United States remained comparatively quiet all this time, so it was most natural to expect a continuation of the disturbance in these parts.

"As it has finally happened this time I believe it is over and the adjustment complete. . . .

"The center of a future earthquake, due perhaps to the same causes as this, will probably be different, and may take place as far away as the other side of the equator."

In a bulletin of the Imperial Earthquake Investigation Committee of Japan, published in January, 1907, Vol. I., pp. 21 and 23, he continues the subject, illustrating the distribution of seismic disturbances by a map, and concludes thus:

"The great stresses going on along the whole Pacific coast of America, which thus resulted in the occurrence of a series of great earthquakes, seem to be connected with the growth of the Rocky and Andes mountain ranges; the Valparaiso earthquake bringing probably the *great* seismic activity along the zone under consideration for the time to an end."

The forecast of an earthquake between Alaska and Mexico was verified by the California shock of 1906 and the forecast of a disturbance south of the equator by the Valparaiso earthquake of 1906. The forecast of immunity for some decades in the Mexico-Central America group was shown to be erroneous by the Mexican earthquake of 1907. The success or failure of the prediction of immunity for other parts of the coast remains to be determined. It is to be noted (1) that the Mexican earthquake, occurring in a district for which Omori predicted immunity, was forecast by both Hayes and Lawson; (2) that Lawson forecasts disturbance in a region north of California for which Omori forecasts immunity, and that Hayes forecasts disturbance for a region south of Mexico for which Omori forecasts immunity. See the following notes.

[9] C. W. Hayes is thus reported in the Washington *Times* of April 16, 1907:

"At least one man, who has studied seismic disturbances, has succeeded in predicting the locality of an earthquake months before the shock occurred.

"He is Dr. Charles Willard Hayes, of the United States Geological Survey, who made a report for the government on seismic conditions in Nicaragua in 1899. In this report he made the statement after the recent destructive earthquake at Valparaiso that he would not be surprised if the next section of the American continent to be visited by a seismic disturbance would be somewhere between San Francisco and Valparaiso, probably in Mexico.

"Dr. Hayes would not be surprised if the next earthquake should occur in the United States of Colombia, South America.

"In speaking of the earthquake in Mexico yesterday Dr. Hayes said to a *Times* reporter this morning:

"'While it is impossible to predict with any accuracy the location and time of the occurrence of an earthquake, our knowledge of the geological structure of the earth enables us to determine within certain limits the probable areas where seismic disturbances are most likely to occur. The course of these disturbances may be expected to follow a general line of adjustment of the earth's crust along the western slope of the two American continents, the line being somewhat broken in Central America.

"'The course from South America extends north to the islands in the Caribbean Sea, and that from North America is traceable down through Mexico and Central America. This course extends north along the coast of Alaska across the Aleutian Islands, down the Siberian coast, through Japan and thence across the Indian Ocean.

"'The disturbance in Alaska a few years ago was the first of the series that has afflicted the western hemisphere recently. It was natural to

Lawson mentioned breaks in the continuity of recent demonstrations, between the southern part of California and Central America, and between the northern part of California and Alaska, and suggested the probability of early visitations in Mexico and the Oregon-Washington region. In this forecast he anticipated by a few weeks the Guerrero earthquake.[10] Omori went farther and expressed the opinion that the Valparaiso earthquake was the final term of a series, and that the whole Pacific coast of America would be exempt for a time from *great* seismic activity. He expected for San Francisco a period of immunity of thirty to fifty years and for coastal regions from Alaska to Ecuador of twenty to thirty years.

expect the next one at some distance, and, as it happened, this occurred at San Francisco. Then the Valparaiso disturbance being so far to the south it was probable that the next shake would be somewhere between the two. The shock at Jamaica was probably connected with the Valparaiso earthquake, being in the same course with it. That in Mexico is more likely to be connected with the course of disturbance from Alaska down.'

"Dr. Hayes, when asked if he would venture to predict the locality in which the next earthquake might occur, said that he did not wish to go on record as making any prediction on a matter concerning which scientific knowledge was so limited, but was of opinion that it would not be unreasonable to look for one in northern South America in the United States of Colombia. Asked whether a disturbance there would be likely to affect the region of the Panama canal, he thought that Panama might feel tremors from a considerable shock, but that it was unlikely any damage would result."

[10] A. C. Lawson, in a lecture read to the National Geographic Society, March 29, 1907, attributed the California earthquake to a series of ruptures that had been traveling along the western coast of America. "So far it has occurred everywhere along the coast except in a stretch between the southern part of California and Central America and an area between the northern part of California and the southern part of Alaska. These stretches, I believe, will be visited before long and then the long line of this earthquake will be complete from Chili to Alaska." This statement preceded by a few weeks the occurrence of the Guerrero earthquake in Mexico, and its prognostication was thus promptly verified as to the district south of California. It awaits verification for the district north of California.

It will be observed that this idea of a series, breaking on the American coast in the course of a few years, and followed by a comparatively long interval before the arrival of another series, an idea apparently shared by Hayes and Lawson, combines rhythm with alternation in the theory of forecasting.

Prediction and verification are the test of hypothesis, and this group of predictions—albeit tentative and advanced with judicious caution—embodying, as they do, the diverse views of independent investigators, who approach the subject from both seismologic and geologic sides, constitute a valuable contribution to seismic forecasting. The outcome in verification will have bearing not only on theories of alternation, rhythm and rhythmic immunity, but on the order of magnitude of the seismic district within which effective mechanical interaction takes place, and also on the profounder earth problems with which the question of the ultimate cause or causes of earthquakes is involved. If it shall appear as highly probable that yieldings to crustal stress in remote parts of North America have a direct influence on the dates of similar events in South America, the primary sources of the stresses can hardly be of such local nature as the shifting of load through degradation and aggradation or the outward flow of continental excess of matter, but should be sought rather in forces tending to deform the planet as a whole.

Trigger.—The third general principle applicable to prediction is that of the trigger—or the principle involved in the parable of the last straw, which broke the camel's back. As the growing earth stress

little by little approaches the limit of the resisting force there is a critical period during which a relatively small additional stress arising from some other source may precipitate the catastrophe. A number of possible sources for the additional stress are known, the influence of several has been fairly demonstrated in a statistical way, and it is on the whole probable that a large majority of earthquakes owe their precise dates to such contributory causes. Many of the precipitating factors are periodic in their character, and the times of their maxima, or other favorable phases, are known; so that, granting their influence, they serve to restrict prediction to certain epochs. They are not of primary importance in forecasting, but when the approximate date of a future earthquake shall have been learned by other means, they will serve to refine the estimate of time.

The principal known causes of periodic variation of stress are bodily tides of the earth; oceanic tides, which alternately load and unload the sea bed near the shore; the winter load of snow on parts of the land; annual and diurnal variations of atmospheric pressure; diurnal variations of barometric gradient; and the wandering of the earth's axis of rotation. The relative importance of the several influences can not yet be indicated, but it is known that their absolute importance is not the same in all places. Three belong to the coastal belts, two to the land; and two belong to land and sea, but vary with latitude. Their relative importance in any particular locality may depend also on the direction of the slowly growing tectonic stress of the crust; for in order to be effective the temporary or adventitious stresses must be of such character as to augment the tectonic stresses. Let me illustrate this point.

The tidal sway of an oceanic basin raises and lowers the surface very little where the water is deep, but has a much greater effect on the shoals bordering coasts. The strip of sea bed following the coast is subjected twice a day to the addition of a heavy load of water, and in the intervening hours is relieved of pressure by the same amount. On the seaward side of the strip there is a gradual change in pressure, and on the landward side, just at the water edge, an abrupt change; and these pressure differences cause strains and stresses in the crust beneath. The directions of the induced strains lie in vertical planes at right angles to the coast, and are competent to increase or diminish tectonic stresses having similar directions. On the coast of Alaska near Mt. St. Elias the tectonic changes in progress include an uplift of mountains parallel to the coast, and the main tectonic stresses may be assumed to lie in vertical planes normal to the coast; so that here the oceanic tides are competent to precipitate earthquakes. But on the California coast near San Francisco, where the directions of the main tectonic stresses are horizontal and are approximately parallel to the coast, the stresses from oceanic tides may be ineffective. On the other hand the stresses created in the crust by the shifting of the axis of rotation are probably better calculated to augment tectonic stresses at San Francisco than at Mt. St. Elias.

Unfortunately the value to the forecaster of the periodic stresses is impaired by the occurrence of other transient stresses which are not periodic. The barometric gradients and extremes of pressure connected with cyclonic storms are of this class, and so are the pressure changes arising when the sea is pushed against the land or drawn from it by strong wind; and all these storm effects are at times much greater than the rhythmic changes of cor-

responding character. If storms are really earthquake-breeders—instead of the traditional calm, sultry, so-called "earthquake weather"—then the shocks they precipitate can be foretold only so long in advance as the storms themselves are foreknown.

The most potent of all precipitants of earthquakes is also useless to the forecaster because its action is unforeseen. It is the earthquake wave emanating from a nearby focus. The response to such an impulse follows the initial shock so closely that the two shocks are combined in a single seismic event—an earthquake with two foci, or a "double-earthquake."

Prelude.—The forecasting of earthquakes by means of prelude has nothing in common with other methods, but resembles rather the forecasting of the weather for the day by a glance at the sky in the morning. It depends on the recognition of premonitory signs, and also, to some extent, on the recognition of the earliest phases of the event itself.

When a fracture or other parting of the rock takes place, the jar which is communicated to surrounding portions of the crust is not a simple impulse, but a congeries of vibrations differing in amplitude and period, and in speed of transmission. At any point of the focus they begin together, but traveling through the rock at different rates, they arrive at any distant point at different times; and the greater the distance the greater their separation. The strongest of the vibrations, or those said to constitute the principal shock, are not the first to arrive, but are preceded by vibrations which are much weaker, and are known as the preliminary tremors. At a point twenty miles from the origin the preliminary tremors are felt four or five seconds before the principal shock. There are also vibrations too minute to be felt, and not yet recorded by the most delicate seismographs, but of such frequency that they fall within the register of the ear and are perceived as sounds, and these usually begin to arrive before the preliminary tremors. The sounds and faint tremors are notes of warning, and to him who not only hears and feels but understands they give command of precious seconds. People who live in earthquake countries and are familiar with these warnings acquire the habit of instantly taking precautionary measures.

Still earlier than the sounds and tremors with which the earthquake begins, are sometimes sounds, tremors or minor shocks, and it is suspected that phenomena of this sort may betray growing seismic activity and thus constitute premonitory symptoms of the final rupture. Little is known of them in any exact way, because they occur at a time when attention is not directed to such matters; and nearly all records are made from memory after the occurrence of the earthquake. If they are veritable preludes, connected in a systematic way with the mechanics of the earthquake, they are probably analogous to the cracklings and crepitations observed in strained beams and strained blocks of rock before collapse occurs. With reference to the possibilities of forecasting, expectation centers especially on faint tremors such as are occasionally perceived a few minutes or a few hours before an earthquake shock. They are more frequently inferred from the peculiar behavior of animals; and after making much allowance for the influence of imagination on the memory of observers, there is still reason to think that various animals are affected by vibrations to which man is insensible, and that their reported uneasiness before earthquake shocks is real and is occasioned by premonitory vibrations.

The scientific study of preludes belongs

to the future, and especially to such adaptations of seismographic appliances and methods as we may confidently anticipate. Feeble tremors, ascribed to minute crepitations of the crust, have already been made audible by means of the microphone, so that the ear could be applied to a sort of seismic stethoscope; and the next step will perhaps be to construct a seismograph of such delicacy as to record these minute vibrations, and install it where it will be undisturbed by tremors of artificial origin.

RÉSUMÉ

Summarizing briefly, many of the malloseismic districts or areas of earthquake danger are known from records of past experience, and others are being recognized by physiographic characters. Within them are tracts of special instability because of the incoherence of the underlying formation, and these can be both characterized in general terms and locally mapped. The general relations of danger to place are so well understood that an early solution of their outstanding problems may be assumed. Of the relations of danger to time much less is known and there is less promise for the immediate future. The hypothesis of rhythmic recurrence has no sure support from observation, and is not in working order for either large or small areas. Its corollary of local immunity after local disaster is more alluring than safe. The allied hypothesis of alternation between parts of a district is being tested by a great example, but the verdict belongs to the future. The hypothesis of precipitation by accessory forces which are in large part periodic and foreknown, has a good status and is being developed on the statistical side. It promises to make the date of prediction more precise if ever the approximate time shall be achieved by other means. The hypothesis of an intelligible prelude has barely been broached and the means to test it are not yet in sight. In a word the determination of danger districts and danger spots belongs to the past, the present and the near future; the determination of times of danger belongs to the indefinite future. The one lies largely within the domain of accomplishment; the other still lingers in that of endeavor and hope.

We may congratulate ourselves that it is not the place factor which lags behind, for knowledge of place has far more practical value than knowledge of time. In fact I see little practical value in any quality of time precision attainable along lines of achievement now seen to be open. Suppose, for example, that a prediction based on rhythm or alternation should indicate an earthquake as due in a certain year, and that tides should be recognized as the most potent accessory cause; then for several days each month, and possibly for many months, expectation would be tense, and the cost in anticipatory terror would be great. Or suppose that prelude phenomena should be found to afford real warning; the forecaster on duty would still have to deal in probabilities, and when in doubt would often sound vain warnings, in the conscientious effort to escape the greater error of omission at the critical time—and again nervous strain would be wasted. And even if warning were definite, timely and infallible, so that peril of life could be altogether avoided, property peril would still remain unless construction had been earthquake-proof. If, on the other hand, the places of peril are definitely known, even though the dates are indefinite, wise construction will take all necessary precautions, and the earthquake-proof house not only will insure itself but will practically insure its inmates.

MORAL

It remains to draw the moral. In view of these facts as to forecasting, and of the further fact that we have in our land a district subject to strong earthquakes, there are duties to be recognized and policies to be advocated. It is the duty of investigators—of seismologists, geologists and scientific engineers—to develop the theory of local danger spots, to discover the foci of recurrent shocks, to develop the theory of earthquake-proof construction. It is the duty of engineers and architects so to adjust construction to the character of the ground that safety shall be secured. It should be the policy of communities in the earthquake district to recognize the danger and make provision against it.

The general fact of local danger spots, where the agitation during strong earthquakes is peculiarly violent, has long been familiar. It is known that they are commonly found in lowlands where the underlying formation is a deep deposit of alluvium or other unconsolidated material, and that such material, while it aggravates great shocks, absorbs and quenches small ones. It is also known that the local phenomena are in some way connected with the transformation of earthquake waves in passing from elastic to inelastic material. But a mechanical theory of the phenomena is yet to be supplied. For economic, as well as scientific purposes, this is one of the important fields for investigation. In Japan, where earthquakes are much more frequent than in any portion of our own land, the subject has been studied and may still advantageously be studied, by the observation of natural shocks. In America the problem can be more readily studied by means of artificial earthquakes in the laboratory, continuing the line of experimentation begun by Rogers.[11] When the underlying principles have become known, it will be comparatively easy for geologists, engineers and architects to estimate the danger factor in places to be occupied by buildings.

The San Andreas rift,[12] now traced through so much of its length as traverses inhabited areas, is recognized as a danger belt of a peculiar character, to be avoided especially by water conduits and railways. Although it is probably the most extensive rift belt in the country, it is not the only one, and the positions of all others should be determined and mapped. The foci or epicenters of recurrent earthquakes are also localities of special danger, even though the underlying formation is firm and elastic. So far as the earthquake faults reach the surface of the ground, the epicentral tracts coincide with the rift belts and fault scarps; but some of the foci are doubtless wholly subterranean and need for their discovery a seismic survey like those conducted in Japan, Italy, England and, since the Valparaiso earthquake, in Chili. In Japan, which now takes first place in the study of earthquakes, the survey is conducted by a system of seismographic observatories in cooperation with a large body of local correspondents—a mode of organization quite analogous to that of our Weather Bureau, with its system of thoroughly equipped stations and its wide-spread corps of volunteer observers.

Much progress has already been made

[11] Professor F. J. Rogers, of Stanford University, gave harmonic motion in a horizontal direction to a box of sand, and found that under certain conditions a body resting on the sand received motion which was not harmonic, and which had greater amplitude and a much greater maximum acceleration than the motion of the box. His experiments are described in the "Report of the California Earthquake Commission," Vol. I., Part II., pp. 326–35.

[12] "The California Earthquake Investigation Commission," Vol. I., Part II., pp. 25–53.

in determining the principles of earthquake-proof construction. After each great earthquake which in modern times has devastated a city, there has been engineering study of the buildings which successfully resisted the vibrations and of those which succumbed, so that the construction of the future might profit by the experience of the past. In various countries, and especially in Japan, there have been series of experiments either for determining the mechanical character of earthquake shocks, or for testing the ability of different types of construction to withstand them. The results of these observations and experiments have helped to determine the building regulations and building methods in various earthquake districts. For our own purposes there are needed, not merely a complication of the principles developed elsewhere and of the deductions from recent experience in California, but special lines of investigation, covering, theoretically and experimentally, the materials and architectural methods employed in this country at the present time. In the line of experiment, we may well follow the example of our oriental neighbors, by constructing a machine which will give to a platform all the motions characteristic of a violent earthquake, and using the platform as a testing ground for types and materials of construction.

The proposition that it should be the policy of the inhabitants of an earthquake district to recognize the danger and make provision for it appears self-evident, but I regret to say that its soundness is not universally recognized in California. As long ago as 1868, Whitney, speaking of the Pacific states, said:

> The prevailing tone in that region, at present, is that of assumed indifference to the dangers of earthquake calamities—the author of a voluminous work on California, recently published in San Francisco, even going so far as to speak of earthquakes as "harmless disturbances." But earthquakes are not to be bluffed off. They will come, and will do a great deal of damage. The question is, How far can science mitigate the attendant evils, and thus do something toward giving that feeling of security which is necessary for the full development of that part of the country.[13]

This policy of assumed indifference, which is probably not shared by any other earthquake district in the world, has continued to the present time and is accompanied by a policy of concealment. It is feared that if the ground of California has a reputation for instability, the flow of immigration will be checked, capital will go elsewhere, and business activity will be impaired. Under the influence of this fear, a scientific report on the earthquake of 1868 was suppressed.[14] When the organization of the Seismological Society was under consideration, there were business men who discouraged the idea, because it would give undesirable publicity to the subject of earthquakes. Pains are taken to speak of the disaster of 1906 as a conflagration, and so far as possible the fact is ignored that the conflagration was caused, and its extinguishment prevented, by injuries due to the earthquake. During the period of after-shocks, it was the common practise of the San Francisco dailies to publish telegraphic accounts of small tremors perceived in the eastern part of the United States, but omit mention of stronger shocks in the city itself; and I was soberly informed by a resident of the city that the greater number of the shocks at that time were occasioned by explosions of dynamite in the neighborhood. The desire to ignore the earthquake danger has not altogether prevented the legitimate influence of the catastrophe on building regulations and building practises, but

[13] "Earthquakes," by J. D. Whitney, *North American Review* for April, 1869, Vol. CVIII., p. 608.

[14] "California State Earthquake Investigation Commission," Vol. I., Part II., p. 434.

there can be little question that it has encouraged unwise construction, not only in San Francisco but in other parts of the malloseismic district.

The policy of concealment is vain, because it does not conceal. It reflects a standard of commercial morality which is being rapidly superseded, for the successful salesman to-day is he who represents his goods fairly and frankly. It is unprofitable, because it interferes with measures of protection against a danger which is real and important.

To understand the practical importance of the earthquake danger, let us for a moment consider it from the insurance point of view. To determine rate of premium, an insurance company first computes the risk, and this computation is based on past experience, comparing the actual losses with the amount exposed to loss. We know, with fair approximation, the loss of life by earthquake in California from the year 1800, and can compare it with the population. As to the property loss, our knowledge is relatively indefinite, but it suffices for the present purpose.

Consider first the value of insurance against the danger of death by earthquake. Seven hundred and nine deaths are reported to have been caused by the San Francisco earthquake, and about 76 deaths by earlier earthquakes, making a total of 785.[15] The total annual population for the same period, that is to say, the sum of the populations for the several years, was about 51,500,000.[16] Using these data, the annual premium on a policy for $1,000, payable only in the event of death by earthquake, is computed at one cent and a half, plus the cost of doing the business and the profit of the company. The minuteness of the earthquake risk may be further indicated by saying that it is one tenth of the risk of death by measles. If a timid citizen of California should emigrate in order to escape the peril from earthquake, he would incur, during his journey, a peril at least two hundred times as great, whether he traveled by steamship, sailing vessel, railway car, motor car, stage, private carriage, or saddle; and if in emigrating he removed from San Francisco to Washington City he would incur, by change in environment as regards typhoid fever, an increment of peril eighteen times as great as the earthquake peril he escaped.[17]

The danger to property is much more serious. Using the same method of computation as before, and availing myself of the expert knowledge of local statisticians, I have made a parallel estimate of the earthquake risk to buildings in California, and find it to be about five hundred times as great as the risk to life. If a company were to undertake the insurance of buildings against injury by earthquake, and base its premium on the experience of the state from 1800 to 1908, the average premium on a policy of $1,000 would be about $7, plus the cost of doing the busi-

[15] The casualties in 1906 are given as reported by the State Board of Health; those in earlier years were compiled from Holden's "Catalogue of Earthquakes on the Pacific Coast, 1769 to 1897."

[16] To obtain this figure the populations of the state on census years were platted on section paper and a curve of population drawn through them, thus graphically interpolating estimates for intervening years. For years earlier than 1850 estimates were based on data contained in Hittell's "History of California." The census returns do not include Indians. In making estimates of the population previous to 1850 the Mission Indians were included. The estimate includes the year 1908.

[17] The U. S. Census returns for the years 1901–5 give the following death rates, per 100,000, from typhoid: San Francisco, 27.0; Washington, 56.6. The statement in the text of course applies only to the risk of death from typhoid; the death rate from *all* causes was higher, in the same years, in the western city than the eastern.

ness.[18] This is nearly twice as large as a similar figure expressing the fire risk for the United States, as based on the accumulated experience of underwriters. Just as in the case of fire insurance, the premium on earthquake insurance would be adjusted to the local conditions; it would be higher for houses on soft ground than for those on bed rock, relatively high for houses near known earthquake foci, and very low for houses classed as earthquake-proof.

In making this estimate the fire damage occasioned by the earthquake damage of 1906 was treated as part of the earthquake damage. Had the direct earthquake damage alone been considered, the computation would have yielded a figure materially smaller, though still comparable with the basal fire insurance factor. But there seems no good reason for excluding the fire damage, for not only was the San Francisco conflagration caused wholly by the earthquake, but fire is a frequent sequel of the wrecking of buildings by seismic shocks. Nearly all our appliances for heating, cooking and lighting are sources of fire danger when deranged by violence to the containing buildings, and if the agent of violence affects a large area, as in the case of earthquakes, the appliances for extinguishing fires are apt to be disabled at the same time.

It is possible that the estimate of the building risk is exaggerated by reason of its having been made just after the great disaster of 1906. It certainly would have been materially smaller if made by the same method just before that disaster. But this qualifying circumstance is largely if not wholly offset by the fact that various shocks of the same physical rank as that of 1906 wrought comparatively little havoc because at the time of their occurrence the areas shaken were sparsely populated—at least by house-building races. The Inyo earthquake of 1872, having its origin in Owens Valley, demolished the village of Lone Pine with a completeness not paralleled in 1906, and the falling walls crushed to death a tenth part of the village population. The shocks of 1812, affecting a tract on which Los Angeles, Santa Barbara and other large towns are now built, were limited in their destructive effect to the Spanish Missions because those were then the only houses; but the mission buildings fared badly, and it is related that thirty or forty mission Indians lost their lives. The earthquake hazard indicated by these occurrences was certainly not less than that emphasized by the recent disaster in a populous district,

[18] In assembling data for this estimate I was greatly assisted by Professors C. C. Plehn and A. W. Whitney, of the University of California, but these gentlemen are not to be held responsible for the estimate itself. The estimate involves, among others, the following assumptions: (1) in that part of San Francisco burned over in April, 1906, the loss from destruction and injury of buildings amounted to one third the entire loss; (2) the ratio of sound value to assessed value of buildings in San Francisco in 1905 was 1.7; (3) the similar ratio for the entire state was 2.0; (4) the average value of buildings per capita in California was the same for the entire period 1800–1908 as for the single year 1905. Some of the elements of the estimate are as follows:

Damage to buildings in burned district of San Francisco in 1906 ($= \frac{1}{3} \times$ \$350,000,000)	\$117,000,000
Damage to buildings in San Francisco, outside burned district, 1906	7,000,000
Damage to buildings outside of San Francisco, 1906	15,000,000
Damage to buildings in California, 1800–1905	20,000,000
Total earthquake damage to buildings in California, 1800–1908	\$159,000,000
Total corresponding "exposure" (= sum of annual value of buildings in California 1800–1908)	\$22,000,000,000
Basal insurance factor (= ratio of total loss to total exposure)	0.00723
Risk on policy of \$1,000	\$7.23

and yet the absolute losses they occasioned were so small as to have little influence on the totals used in the computation.

On the whole, weighing these and other factors of the problem as well as I am able, I am disposed to adhere to the estimate, not, indeed, claiming for it a high measure of precision, but regarding it as a fair approximation to the truth, and possibly as good as may be derived from the available facts.

It is needless to carry further the discussion of insurance rates. Its purpose has been served in showing that the earthquake risk to buildings in California is comparable with the fire risk and equally worthy of serious consideration. There is no present question of earthquake insurance, of which the function would be merely to distribute earthquake losses, but there is a question of the prevention of earthquake damage.

Earthquake damage is at least as preventable as fire damage. It is possible so to construct houses that they will neither collapse nor otherwise be vitally injured by such shocks as have visited California in the past. In a house so built there will be small danger from earthquake-started fires because they will be both accessible and quickly detected. It is wreckage that prevents the prompt extinguishment of the initial blaze. In a house so built there will be little damage to furniture, merchandise and other valuable contents. With houses so built the life risk will become a vanishing quantity, for practically all earthquake casualties are directly due to the failure of buildings. And in a community thus protected in life and property the terror of the mysterious unheralded temblor—a factor far outweighing the actual personal peril—will gradually wear away.

In saying that earthquake damage is preventable I would not be understood to imply that the subject of earthquake-proof construction is at all adequately developed. Competent modes of construction are known, but the best modes, the most economic modes, the modes best adapted to American materials and conditions remain to be determined, and there is much need of investigation.

It should be the policy of the people and state of California to see that the necessary investigations are made, and that the results are embodied in the building regulations of all cities as well as in the entire building practise of the state. And, in order that the methods of construction may be properly adjusted to the very unequal local requirements, provision should be made for a seismic survey and the mapping of tracts of special earthquake danger.

G. K. GILBERT

JEAN ALBERT GAUDRY[1]

FROM time to time as honored chieftains fall in the front ranks of the world's intellectual forces that are making for scientific progress, and bent on the conquest of new realms of knowledge, it befits men of a younger generation to take note of the passing of these heroes, these veteran standard-bearers who now rest from their labors, leaving a splendid memorial of their lifework behind them. Upon such occasions it is well to call to mind some of the more notable achievements of these patient searchers after truth, and to bethink ourselves what manner of men were they who contributed largely to widening the bounds of human understanding, whose lives were consecrated to the service of the sovereign mistress of truth.

An occasion of this kind has recently befallen us. Geological and biological science mourn the loss of Professor Albert Gaudry, foremost of the modern school of French paleontologists, a man of remarkable and versatile talents, in-

[1] Presented before the American Society of Vertebrate Paleontologists at the Baltimore meeting, December 30, 1908.

vestigator, teacher and author of far-reaching influence, and not less distinguished as a naturalist than universally beloved for his sweet simplicity of character and attractive personality. In him were happily combined that temper of mind and delicate sensitive spirit which proclaimed him not only as a fine type of the cultured scientific gentleman, but revealed him likewise as an *homme de cœur,* rich in human sympathy. Greatly as we deplore his loss, we may be glad that such a shining exemplar has graced our science. It is pleasing to contemplate him as a naturalist and interpreter of nature, but better still as a humanist. We honor him for his devoted service, we revere him for the lofty ideals he realized as a man. Much is expressed in the title by which his pupils and colleagues scattered over two continents were wont to address him: *maître vénéré.* His predominant trait was rightly characterized in an address delivered by his successor in the museum, Professor Boule, on a memorable occasion in the spring of 1903: "L'essence de votre nature, cher maître, c'est la bonté même." All who have enjoyed the privilege of personal acquaintance with the late president of the institute will concur in that sentiment.

The main facts in the life history of Professor Gaudry are briefly told. Born at Saint-Germain-en-Laye, near Paris in 1827, eldest son of a well-known advocate, as a youth fond of natural history pursuits and amateur collector of fossils at Montmartre, awarded the degree of doctor of science at the age of twenty-five and appointed assistant professor of paleontology at the Paris Museum the following year, we find him undertaking his first serious work as a naturalist whilst engaged on a scientific mission to the Orient and islands of the Ægean in 1853. His first publications date from the same year, and at this time he began his long-continued and classic studies of the late Tertiary vertebrate fauna at Pikermi in Attica. The results of this work, published 1862–7, under the title of "Animaux fossiles et géologie de l'Attique," together with its sequel on fossil vertebrates from Mont Léberon, won for him recognition as a leader in his special field, and constitute probably his most enduring monument in the province of descriptive paleontology. Other technical memoirs followed, among which it will suffice to mention those on *Actinodon* (1887), *Dryopithecus* (1890), pythonomorphs (1892) and Patagonian vertebrates, the last subject being one upon which he was still engaged at the time of his death, on the twenty-seventh day of November, 1908.

Excellent as are these special monographs, it is through his more popular, or at any rate less strictly technical, or perhaps we should say more broadly philosophical, writings, that Gaudry's name is most widely known both among his own countrymen and abroad. These brilliantly written essays, published in tripartite series during the years 1878–96, the first having for title "Les Enchaînements du monde animal," have exercised an incalculable influence in spreading evolutionary ideas and inculcating sound notions of paleozoology. It has been said that a philosopher is always something of a "poète manqué." This quality on the part of the author is strongly marked in the three volumes in question, and manifests itself not only in style, but in ideas, not only in the main theme under discussion, but in many a charming and naïve excursus, the effect of which is to make his work most exhilarating reading. His object is to present, as he tells us in one place, some things to instruct the mind, and yet others to satisfy the soul. And we must admit that he succeeds very well in both these aims. He was artist to this extent at least, that he sought in nature an ideal standard of truth and beauty, and made that standard effective in all human relations.

To the typical French mind, as to the ancient Greek, is commonly attributed a quick and accurate intuition, facile power of generalization, and a fondness for broad, comprehensive views as applied to any subject. Professor Gaudry well exemplified these racial characteristics. An analyst so far as involves the merely mechanical collection of facts, his genius consists in synthesis, in the rational coordination of his material after it has been laboriously brought together. In the early days of evolutionary discussion he incurred

reproach for being a *too* brilliant theorist. Time has since justified his keen sense of discrimination, his rigid intellectual candor, and subtlety in drawing right conclusions, not only in those momentous issues, but in most of his later philosophical writings. His work obviously has enduring qualities; his positive results are gained for all time, and become the heritage of science.

One further feature deserves to be pointed out. Professor Gaudry was always consistently opposed to the idea of following a scientific pursuit from primarily mercenary motives. He warns young men of the necessity of cultivating higher ideals of their chosen calling. His words seem to reecho those of Francis Bacon, who long ago complained that "men have entered into a desire of learning and knowledge, sometimes as if there were sought in knowledge a shop for profit and sale; and not a rich storehouse for the glory of the Creator and the relief of man's estate." On the other hand, his career reminds us more emphatically than any precept, that in order to attain the repose and exaltation of soul that come after a lifetime of worthy effort and resources nobly expended—"it is worth while in the days of our youth to strive hard for this great discipline; to pass sleepless nights for it, to give up to it laborious days; to spurn for it present pleasures; to endure for it afflicting poverty; to wade for it through darkness, and sorrow, and contempt, as the great spirits of the world have done in all ages and all times."

Finally, no truer thing could be said of Gaudry than one of the most graceful and talented of French writers—Flaubert—said of himself: "Je fais tout ce que je peux pour élargir continuellement ma cervelle et je travaille dans la sincérité de mon cœur; le reste ne dépend pas de moi."

C. R. Eastman

Harvard University

SCIENTIFIC NOTES AND NEWS

Mr. Alexander Agassiz and Professor Theobald Smith have been appointed delegates from Harvard University to the Darwin Celebration at Cambridge University, England, in June, 1909.

The Académie Royale de Médecine de Belgique, at its meeting of December 26, last, elected Dr. Charles S. Minot, of the Harvard Medical School, a foreign corresponding member of the academy.

M. P. Villard has been elected to succeed M. Mascart as a member of the Paris Academy of Sciences, in the section of physics.

Dr. Henry E. Crampton has been appointed curator of the department of invertebrate zoology in the American Museum of Natural History, to fill the place made vacant by the resignation of Dr. William M. Wheeler. He will retain an official connection with Columbia University, where he now is professor of zoology in Barnard College. Dr. Frank E. Lutz, investigator in the Station for Experimental Evolution of the Carnegie Institution, has been appointed an assistant curator in the museum. Dr. Alexander Petrunkevitch has become officially connected with the museum as honorary curator of the Arachnida.

President Eliot has purchased a house on Brattle Street, Cambridge, which he will occupy after leaving the residence provided by Harvard University for the president.

Dr. H. C. Chapman, professor of the institutes of medicine and medical jurisprudence at Jefferson Medical College, and for thirty-two years a member of the faculty, has resigned, his resignation to take effect in May next.

Governor Guild, of Massachusetts, has been elected president of the American Forestry Association to succeed President Wilson.

Professor Robert Koch has been elected a president of the German Central Committee for the Prevention of Tuberculosis, in the room of its founder, the late Herr Friedrich Althoff, ministerial director of the Prussian Education Office.

Dr. and Mrs. W. A. Murrill are in Jamaica to study and collect fungi in the interests of the New York Botanical Garden.

PROFESSOR HIRAM BINGHAM, of Yale University, after attending the pan-American Scientific Congress that has just closed at Santiago, Chile, left for southern Peru, to engage in historical research.

LIEUTENANT BOYD ALEXANDER left England on December 12 with the object of thoroughly exploring the islands of São Thomé, Principe and Annobon, chiefly from a zoological point of view.

DR. SVEN HEDIN has visited Japan on his way home and has there received various honors, including the medal of the Japanese Geographical Society. Twenty-nine years ago the late Baron Nordenskiöld, after his accomplishment of the northeast passage, received from the society its medal, and a similar medal was afterwards awarded to General Fukoshima for his ride through Siberia. Dr. Hedin, it seems, is only the third who has received this medal, and the only two foreigners who have been awarded this honor are Swedes.

AT the meeting of the College of Physicians, Philadelphia, on January 6, the following officers were elected: *President,* Dr. James Tyson; *Vice-president,* Dr. G. E. de Schweinitz; *Censors,* Dr. Richard A. Cleeman, Dr. S. Weir Mitchell, Dr. Louis Starr and Dr. Arthur M. V. Meigs; *Secretary,* Dr. Thomas R. Neilson; *Treasurer,* Dr. Richard H. Harte.

AT the December meeting of the St. Louis Chemical Society, the following officers were elected for the ensuing year: *President,* H. E. Wiedemann; *Vice-president,* C. J. Borgmeyer; *Recording Secretary,* Geo. Lang, Jr.; *Corresponding Secretary,* J. J. Kessler; *Treasurer,* A. A. Kleinschmidt; *Councilors,* C. E. Caspari and Leo Suppan.

DR. HENRY PRENTISS ARMSBY, director of the Institute of Animal Nutrition of the Pennsylvania State College, delivered a course of four lectures on the Principles of Animal Nutrition at the New York State Agricultural College, at Cornell University on January 12–15.

ON February 27, Professor Charles E. Lucke, head of the department of mechanical engineering of the Schools of Mines, Engineering and Chemistry, of Columbia University, will speak on the general subject of "Gas Power" before the Society of Arts of the Massachusetts Institute of Technology.

PROFESSOR HARRY GOVIER SEELEY, at one time professor of geology and geography in King's College, London, author of numerous contributions to zoology and paleontology, especially on fossil reptiles, has died at the age of seventy years.

BY will of the late Professor Albert Gaudry, thrice president of the Société Géologique de France, that body receives a bequest of forty thousand francs, the income of which is to be applied in making suitable awards in recognition of meritorious work done in geology or paleontology, either by Frenchmen or foreigners. A portion of the fund may also be used in aiding deserving students in these branches.

THE late Professor Sacharjin has left two millions of roubles for the erection of a hospital in Moscow.

THE prize of the King of Belgium of the value of 25,000 francs will be awarded this year to the author of the best work on aerial navigation.

THE prize of five hundred dollars which is offered biennially by the Association of the Alumni of the College of Physicians and Surgeons, Columbia University, will be awarded in June, 1909. Essays in competition for the prize must be forwarded to Dr. H. E. Hale, 752 West End Avenue, New York, on or before the first of April.

IT is announced that the recent fire at the Geological Survey building on F Street in Washington destroyed property to the value of about $16,000. Ten thousand dollars' worth of surveying instruments were destroyed, and an expenditure of $2,000 will be necessarily incurred for rewiring the building. The offices of the survey, like those of many other government bureaus in Washington that occupy rented buildings, are full of wooden partitions and other inflammable material, exposing valuable public property to the danger of destruction by fire at any time.

IN view of the scientific interests of the volcanic formation within the Rio Grande and

Cochetopa national forests in Colorado, President Roosevelt has made them a reservation under the act for the preservation of American antiquities. The district will be known as the Wheeler National Monument.

At the invitation of Mr. George Otis Smith an informal conference was held at the Cosmos Club, Washington, D. C., on January 2, 1909, for the purpose of discussing the progress of geologic work and with a view to bringing about a better coordination of the various investigations now being carried on. Professor T. C. Chamberlin presided at the meeting and of those invited to attend there were present: F. D. Adams, H. Foster Bain, Joseph Barrell, R. W. Brock, A. H. Brooks, Samuel Calvin, M. R. Campbell, T. C. Chamberlin, W. B. Clark, J. M. Clarke, Whitman Cross, H. P. Cushing, Arthur L. Day, B. K. Emerson, S. F. Emmons, N. M. Fenneman, H. E. Gregory, Arnold Hague, C. Willard Hayes, J. P. Iddings, Arthur Keith, H. B. Kummel, A. C. Lane, Waldemar Lindgren, A. P. Low, W. C. Mendenhall, H. F. Osborn, T. W. Stanton, C. R. Van Hise, A. C. Veatch, David White, H. S. Williams, Bailey Willis.

The Sheffield lectures at Yale University will be given this year, with two exceptions, by members of the scientific school faculty, The lectures will be illustrated and will be delivered on Friday evenings as follows:

January 15—"Growth of the North American Continent during Geologic Times," by Professor Charles Schuchert.

January 22—"The American Gem Stones," by Professor William E. Ford, '99 S.

January 29—"Paper Making from Wood," by Dr. Arthur L. Dean, '02 Ph.D.

February 5—"Dinosaurs: their Evolution and Distribution," by Professor Richard S. Lull.

February 12—"The Modern Steel Bridge," by Professor John C. Tracy, '90 S.

February 19—"The Safety Devices of the Human Body," by Professor Lafayette B. Mendel, '91.

February 26—"Influence of Geology on the History of Jamaica," by Dr. Rossiter W. Raymond.

March 5—"Recent Discoveries in Electricity and some of their Consequences," by Professor Lynde P. Wheeler, '94 S.

March 12—"The Iron Resources of the United States: their Past and Future," by Professor John D. Irving.

March 19—"Land Reclamation in the United States: the Problems, the Opportunity," by Dr. George T. Surface.

A statement regarding the anthracite industry of Pennsylvania has been prepared by Wm. W. Ruley, chief of the Bureau of Anthracite Coal Statistics, of Philadelphia. Mr. Ruley estimates that the shipments of anthracite for 1908 were 64,237,076 long tons, against 67,109,393 long tons in 1907, indicating a decrease of 2,872,317 long tons, or 4.28 per cent. If the quantity of coal sold to the local trade and used at the mines decreased in the same proportion, the total production in 1908 amounted to approximately 73,200,000 long tons, as against 76,432,421 long tons in 1907. Reports received by Edward W. Parker, statistician, of the United States Geological Survey, from state officials and others closely in touch with the coal-mining industry in the several states indicate that the output of the bituminous coal mines of the country in 1908 was between 320,000,000 and 330,000,000 short tons. If the final returns are found to agree closely with these preliminary figures they will indicate a decrease in production of 15 to 20 per cent. as compared with the production in 1907.

The Third Congress on School Hygiene will be held in Paris from March 29 to April 2, 1909. There will be an exhibition in connection with the congress. The congress held its first meeting at Nuremberg in 1904, and its second in London in 1907.

UNIVERSITY AND EDUCATIONAL NEWS

Gifts to the amount of $346,466.05 were announced at the recent meeting of the trustees of Princeton University, of which the largest, $200,000, was that of Messrs. David B. Jones and Thomas D. Jones, of Chicago, for the Palmer Physical Laboratory endowment fund. Other gifts were $25,370 from the committee of fifty and $34,377.07 from the General Education Board.

More than $40,000 has been subscribed towards a fund of $100,000 to endow a chair of physiology at the University of Cincinnati, in honor of the late Joseph Eichberg.

IT is announced by President John Thomas, of Middlebury College, that \$91,685.50 has been contributed toward the \$100,000 needed to secure the D. K. Pearson building and endowment fund of \$100,000.

BY the will of Dr. James G. Wheeler, Broughton, the James Millikin University, Decatur, will come into possession of his estate, estimated to be worth from \$75,000 to \$125,000.

THE Ohio State University has received a gift of \$10,000 from Mr. Robert T. Scott, Cadiz, the income to be used for the aid of poor students.

THE medical department of the University of Pennsylvania, has concluded arrangements for holding the first annual "Home Coming, or Progressive Medicine Week," to be given for the benefit of the alumni of the school, and to occupy the Easter vacation period. Plans are being considered to have each head of a department arrange, with the cooperation of his assistants, a program which will note deviations from the old standards, as well as lay stress upon principles which by constant practise have become crystallized. The alumni of the medical school who have distinguished themselves in their profession will be invited to cooperate.

ABBOTT LAWRENCE LOWELL, since 1900 professor of the science of government in Harvard University and previously since his graduation from Harvard College and the Law School a lawyer practising in Boston, will succeed Mr. Eliot as president of Harvard University.

DR. CHARLES H. HASKINS, professor of history in Harvard University, has been appointed dean of the Graduate School of Arts and Sciences, to succeed the late Professor John Henry Wright.

DISCUSSION AND CORRESPONDENCE

PECULIAR ELECTRICAL PHENOMENA

IN an article by Professor J. E. Church, Jr., in SCIENCE, November 6, 1908, page 651, entitled "Electric Disturbances and Perils on Mountain Tops," Professor Church describes the peculiar brush discharges that emanated from the weather vane, the anemometer cups and other objects in an electric storm on Mount Rose, on October 20, 1907, between 6:30 and 7:30 P.M. He states also: "Whenever our hands arose in the air, every finger sent forth a vigorous flame."

It may be interesting to note that we find descriptions of similar phenomena in the Elizabethan era, and even in the days of Julius Cæsar. In the "Itinerary of Fynes Moryson" (Macmillan, 1908), Vol. 3, pp. 74–76, there is given an account of an electric storm on the night of December 23, 1601, at Kinsale, near Cork, Ireland. This storm, which took place in midwinter, and in a locality that was practically on the sea level, was preceded by "great lightning and terrible thunder" on the night of December 20, and by "continual flashes of lightning" on the night of December 21.

The following is Moryson's account:

> All the night was cleare [*i. e.*, brilliant?] with lightning (as in the former nights were great lightning with thunder) to the astonishment of many in respect of the season of the yeare. And I have heard by many horsemen of good credit, and namely by Captaine Pikeman, Cornet to the Lord Deputies troope, a Gentleman of good estimation in the Army, that this night our horsemen [who were] set to watch, to their seeming did see Lampes burne at the points of their staves or speares in the middest of these ightning flashes.

Again in North's "Plutarch," "Life of Julius Cæsar" as quoted in Porter and Clarke's edition of Julius Cæsar, p. 119:

> Strabo the Philosopher writeth that divers men were seene going up and down in fire; and furthermore, that there was a slave of the soldiers that did cast a marvellous burning flame out of his hand; insomuch as they that saw it thought he had been burnt, but when the fire was out it was found he had no hurt.

Shakespeare has embodied this account of Plutarch's in his tragedy of Julius Cæsar, Act I., Scene 3, lines 15–25. See also Burritt's "Geography of the Heavens," revised edition, New York, 1859, p. 155, for a reference to a somewhat similar phenomenon as observed by Baccaria.

HENRY PEMBERTON, JR.

RAILROAD RATES FOR THE BALTIMORE MEETING

To the Editor of Science: It has been the custom for many years past to obtain a railroad rate concession for the meeting of the American Association for the Advancement of Science and the affiliated societies. Formerly this was granted at one and one third—a rate, even at that time, far in excess of what could be obtained by a single professor who wished to conduct a handful of students on a geological excursion. To this rate was later added the twenty-five cents validation fee. Then came the concession of two cents per mile, for the Chicago meeting of 1907–8, a rate practically equivalent to the ordinary charges of the roads, to which must be added the validation fee. This year, the arrangements have been exceedingly liberal—one and three fifths plus the validation fee. Taking the rate from Philadelphia to Baltimore as an example: the one fare, $2.40, and the three fifths, $1.44, plus the validation fee, $0.25, amount to $4.09, a sum in excess of the regular round-trip fare of $4.00.

I am aware that for those attending the meeting from a long distance, the rate granted *may* mean a slight reduction, but, even the scientific world is not made up of altruists, and members from the nearer localities will not pay more for their tickets than the ordinary round-trip fare, and trouble themselves besides to obtain certificates, deposit them for validation, call for them, and re-sign for the return trip—four unnecessary wastings of time—for the sake of accommodating those from a longer distance, and there is thus a possibility that the certificates presented may fall short of the required number, with the result of adding greatly to the expenses of members from a distance who put faith in the certificate plan.

I do not know, nor care to know, who is responsible for this most remarkable rate, but I do know what has been done by private individuals, and I am convinced that, with an organization so numerically strong as the American Association for the Advancement of Science and the affiliated societies at its back, the committee, if it be indued with a real desire and determination to obtain concessions that are worth while, will never again offer to the most powerful scientific body of the United States, an illusory grant.

H. Newell Wardle

QUOTATIONS

HARVARD'S NEW PRESIDENT

It would appear that all the recognized demands, exacting though they are, have met satisfactory compliance in to-day's selection of a president of Harvard. Professor Lowell's attainments as a scholar, although well known for many years to the inner circle, have recently received new recognition, both in America and abroad. It is quite beyond question that his recent notable volumes on "The Government of England" have placed him first among contemporary American scholars in the field of political science. To his skill as an administrator the success of the Lowell Institute affords striking testimony, while his deep and active interest in educational questions has received proof in his effective service as a trustee of the Institute of Technology and as a member, for nine years past, of the Harvard faculty. He is a Bostonian by inheritance, by nativity, and by tradition. He is a Harvard man by education, both collegiate and professional; the university can claim no stancher allegiance than his has been. At fifty-two nature has permitted him to retain a nimbleness of mind and body which in the case of most men takes its departure at a much earlier age. Indeed, from every point of view his selection seems obvious, logical and fortunate.

The hand of the president is potent at Harvard; more so perhaps than in any sister institution. Harvard government is that of a limited monarchy, but with the right type of monarch the administration can be made to veer pretty close to the status of a benevolent despotism. To say that it has veered in this direction during the last two or three decades is the highest tribute one may pay to the consummate skill and personal power of President Eliot. But this very development, this centralization of power, influence and responsibility which the retiring Nestor among

college presidents has brought into being will serve to make his mantle fall heavily upon him who must now take it up. To bear it as it has been borne will prove no easy task.—*Boston Evening Transcript.*

SCIENTIFIC BOOKS

ELIOT AND THE AMERICAN UNIVERSITY[1]

FORTY years ago, there was chosen to the presidency of Harvard College, a young professor of chemistry, who had none of the qualities then commonly supposed to be necessary in the position which he held. He was not a clergyman, not a teacher of philosophy, not venerable and not spiritual, merely young, industrious, clear-sighted, scholarly and fearless. Harvard College was in those days only a small institution, chiefly for boys, "a respectable high school where they taught the dregs of learning," as its most popular teacher then described it. Still it was the best we had and our own "our oldest, richest and freest university," even as it is to-day.

In 1868, the young president found an institution of the old type, with some most charming and gifted professors, and others dry as dust. Its work was all elementary in character, the subjects taught were held to be of unequal value, the Greek and the Latin standing in official precedence. Of advanced study there was little, and that little existed in the unique personality of Louis Agassiz and of Asa Gray. It was essentially a boys' school, and a school of the type which forces set tasks on unwilling youth. One of the graduating class of 1873 said to the present writer, at the time that in his class there were but two men (J. W. Fewkes was the other) "who had any interest in natural history or in anything else." Doubtless this was an exaggerated statement, but it represented fairly the attitude of the college boy in those days of prescribed courses and text-book recitations in elementary subjects. In those days, too, the professional schools had no foundation in science or in culture, and the instruction given in them was guiltless of pedagogic methods or ideals. In almost all departments of Harvard College advanced education was a grind rewarded by a degree. The degree was a badge of social and intellectual achievement, not a disclosure of the secret of power.

[1] "University Administration," by Charles W. Eliot, Boston, Houghton, Mifflin Co.

To change all this was not an easy task, and the young president had grown middle-aged before the greater part of his work was achieved. He rightly interpreted his position as representing in no sense a fact accomplished. It was of necessity a continuous struggle; a struggle for greater means, for better men and for higher ideals. An American university is never finished.

Fortunately for himself and for the nation, Dr. Eliot has lived to wear out all opposition; he has seen Harvard College made over after his own fashion, and he has seen it lead the race in a long procession of institutions, one and all endeavoring to follow in its trail. The various impulses of originality in other institutions, notably those originating with Andrew D. White, at Cornell, and with Daniel C. Gilman, at Johns Hopkins, have been absorbed by Harvard, and in general carried to the greatest success yet possible under American conditions. To Cornell we owe originally the doctrine of the democracy of studies, the idea that no one shall say which subject or which discipline is best until we know the man on whom it is to be tried. To Johns Hopkins we owe the idea that advanced work in any subject has a greater culture value than elementary work in the same or other subjects. Both these doctrines have found their place in the elective system at Harvard.

In the lectures on university administration at Northwestern University, President Eliot explains in detail, in simple undramatic fashion, the plan of his work at Harvard, its methods and its results. That the most successful of college administrators should regard the methods which he has himself used as typical and desirable, is natural enough. If other methods had seemed better, he was perfectly free to use them. This volume is therefore an exposition of what Harvard actually is, and the reasons why it is so, in so far as these depend on administrative methods of

any sort. The book is the best of reading for college men, and to the college president it is a veritable hand-book full of suggestiveness on every page.

The board of university trustees at Harvard numbers seven, with the president of the university as the executive head. This number is most favorable to the management of business, and this relation the one most likely to insure devotion and continuity in executive affairs. The disadvantages of large boards, of honorary, ex-officio and absentee trustees, clearly appear in the light of Harvard's experience with a better way. The importance of beginning with young men appears here as elsewhere, and with this Dr. Eliot has the significant remark, "Strangers will, as a rule, not make so good trustees as the children of the house."

In the suggestions as to professors' salaries, Dr. Eliot is rather conservative, especially as regards the younger men, although the professor is better paid at Harvard at present than in any other American college or university. The instructor, he thinks, should begin on the amount a young unmarried man can manage to live on. After a few years of annual appointment, a permanent position with a small increment should be given, and still later, as assistant professor, he should receive a sum on which he may marry but without luxury or costly pleasures. At forty, if growth goes on, the teacher may hope for a professorship, and a full salary at fifty or fifty-five. One difficulty in all this comes from the fact that growth is largely conditional on travel, and travel is a "costly pleasure." To starve a man until he is forty is not to provide for a productive career for the fifteen years that follow.

In all financial matters, President Eliot has been preeminently practical, and the paragraphs relating to the business affairs of the college are thoroughly wise and pertinent. The exclusion of the college president from initial responsibility in these matters is a mistake, and one which has been adopted in too many of our institutions.

The coordination of the influence of the alumni, as represented by the board of overseers at Harvard, is a matter on which Dr. Eliot justly lays especial emphasis.

In the development of the faculty at Harvard, stress has been laid on the individual teacher rather than on the department. As a result of this the department or group executive appears rather as a servant or representative, than as a director or manager of his colleagues. The president stands in the same relation to all the various groups. The system, in vogue in many institutions, by which the professors are brought together into groups under the headship of some dean, who rules over them, the dean in turn ruled over by the president, has never taken root at Harvard. Deans, or sub-executives, are doubtless necessary in large institutions, but they should not be created until they are needed. Above all, what is needed by the executive in all branches is not so much authority to execute as the power and the duty to initiate. Nowhere is the necessity for the concentration of initiative so important as in the duty of the nomination of professors. President Eliot shows clearly the reasons why formal faculty initiative fails in this regard. But there are good reasons why formal faculty acceptance of such nominations is also most desirable. No professor should be added to the faculty against the sober judgment of those who may be his colleagues.

President Eliot devotes one optimistic chapter to the consideration of the greatest of his educational innovations, the elective system. This system has everywhere and of necessity replaced the classical system, which considered but two or three of the many phases of scholarship and life. For Greek-minded men, to use Emerson's phrase (and a very noble type of men they are) the classical training gave a basis of scholarship on which later studies could build to advantage. But the great body of our youth of promise are anything but Greek-minded, and the old classical course opened to them no door worth their entering. The elective system opens many doors and admits many types of men. No two men need exactly the same sort of training for their own best development. The student is a better judge of his own needs than

any group of educational philosophers who have never known him. Here, as elsewhere, the student learns from his own mistakes. Moreover, the elective system brings the student in contact with the best teachers he knows, and the teacher in turn is refined and stimulated by the students who have chosen his work. To the patchwork courses which followed the break-up of the classical system, the elective courses are in every way to be preferred. The mind is made strong by the continuous study of something, and in prescribed courses made up of odds and ends unrelated to any central purpose, thoroughness in any line is impossible. At the present time there is a distinct reaction against the elective system, but not in favor of any other system which has been actually under trial. The elective system will not make scholars out of rich and idle lads whose only interests in college are in games and social pleasures. Once in a while such a one is reclaimed, but the percentage is too small to justify the effort. The elective system is as good as any other system for such as these, but no system will make a man out of a boy who has himself no interest in the process. It is the duty of the college to withhold its degrees from idlers of whatever class. To give the titles of higher education where the substance is lacking is to cheapen our own work. The remedy for slipshod college work is found in the scholarship committee, rather than in the arrangement of courses of study. The final answer to criticisms of the elective system is to recognize its occasional abuses by professors as well as by students, and to ask, what else will you put in its place?

Doubtless a prescribed course is sometimes effective, as in engineering or in medicine, but only where it is prescribed by the nature of the subject. Mathematical subjects are linked together, one dependent on another, and the student desiring mathematics makes no complaint of this prescribed order. But for courses of mixed science, literature, art and philosophy, so many units of one, so many of another, disjointed fragments brought together in the name of culture, the student can have no respect. Required courses of this fashion have passed away never to return. The checks on the elective system must come from the student himself. He must be trained to guard himself from premature specialization on the one hand and from limp diffuseness on the other. If he is a real student, the safe mean leans strongly toward the side of specialization, for after all this is but another name for thoroughness. "The mind is made strong by the thorough possession of something."

The writer once heard President Eliot disclaim any unusual degree of prophetic vision, allowing for himself only an honest industry, attacking one problem as it arose after another, with such solution of each as might be within the range of practical action.

One of Dr. Eliot's predecessors in Harvard was once complimented on the logical coherence of his sermons. He disclaimed all special excellence in this regard. "I write one sentence," he said, "then I thank God and write another." President Eliot has himself accepted this definition of his method. One thing done, he turns to and does the next, and this is the essence of his educational foresight. He does the next and the next, never stopping with the first result or the first achievement; and thus he has made of the administration of Harvard a continuous struggle, while all our other colleges have followed near or far along the same lines of progress.

And to the young man on whom his mantle shall fall, the administration of Harvard will still be a struggle. Nothing is completed, nothing is settled, nothing is final. New lines of development will follow swiftly on the old. The university must be separated from the college, and must be devoted wholly to the work of men as distinguished from the work of boys. All trace of the trade school must be eliminated from the training of professional men. The university professor on the firing line of scientific advance must be maintained and appreciated and none the less the college teacher whose first aim shall be to develop the boy into the sound, sober and enlightened man. The unification of higher education has been in a degree accomplished.

The substantial requirements for entrance, the broad outlook of the elective system, the intensive thoroughness of the graduate professional school, the glorification of the spirit of research, all these are exemplified in the Harvard of to-day. The Harvard of to-morrow will lead in the differentiation of the work of men, the separation of boys and boys' teachers from men and men's teachers. It will not be Harvard College as it was, nor interchangeably Harvard College and Harvard University as it is to-day. It will be a university resting on a college foundation, a university worthy of the eighty millions of free men who form its constituency, a university fit to frame the highest aspirations of the noblest youth of the republic.

David Starr Jordan

SCIENTIFIC JOURNALS AND ARTICLES

It is ever a wonder to us in America that German biologists can so easily start and maintain a new periodical. No sooner does a science become well defined and gain a number of workers than the proper periodical is forthcoming. These remarks are called forth by the appearance of the *Internationale Revue der gesamten Hydrobiologie und Hydrographie* (Leipzig: Klinkhardt), of which the first (double) number appeared in May. The backing of the magazine is indicated by the names on the cover. R. Woltereck (of Leipzig and Lunz) is the editor. B. Helland-Hansen (Berlin), G. Karsten (Bonn), A. Penck (Berlin), C. Wesenberg-Lund (Hilleröd), R. and F. Zschokke (Basel) are the other members of the editorial staff. The Prince of Monaco, Agassiz, Chun, Forel, V. Hensen, R. Hertwig, Murray, Nansen, O. Pettersson and Weismann have lent their names to the undertaking. The first number contains 307 octavo pages, of which the first half contain original contributions; those of Weismann, Murray, R. Hertwig and Issel being essays written especially for the introduction of the new journal. A paper by Nathansohn begins a projected series on the biology of the plankton; one by A. Fischel deals with very successful intravitam staining of *Cladocera;* one by Klausener treats of the annual cycle of the fauna of alpine lakes; and one by Götzinger in the first part of a monograph on Mitter Lake at Lunz, in the Austrian Alps. The remainder of the number contains abstracts of reports, summaries of results, critical reviews, notices from stations and a list of recent literature. There are eight plates and numerous text-figures. Certainly the periodical starts out with the highest ideals and it will be a great stimulus to hydrobiology. It deserves, as it will receive, the most active support of the numerous American workers in this field. C. B. D.

The Independent begins with its issue for January 7, 1909, a series of articles on the fourteen universities of this country, written by Dr. Edwin E. Slosson, of the editorial staff and previously professor of chemistry in the University of Wyoming. Harvard is the first institution discussed and the others to follow in the order named at intervals of one month are: Yale, Princeton, Pennsylvania, Chicago, Johns Hopkins, Stanford, California, Michigan, Wisconsin, Minnesota, Illinois, Cornell and Columbia.

BOTANICAL NOTES

TREES AND FORESTRY

The University of California has done well in publishing Mr. N. D. Ingham's bulletin (No. 196) on "Eucalyptus in California." In 88 pages the author by means of plain descriptions and 70 excellent half-tones gives his readers some very clear and usually very new ideas as to these wonderfully interesting trees as they grow in California.

Major George P. Ahern's "Annual Report of the Director of Forestry of the Philippine Islands," for the year ending June 30, 1907, is of interest to forestry students in this country as showing the considerably different problems which pertain to work in the islands. Two maps help to give a clearer idea as to the available forest tracts in Negros Occidental and Mindoro.

Two years ago Rolland Gardner, of the timber-testing laboratory at Manila, published a bulletin (No. 4) on the "Mechanical

Tests, Properties and Uses" of thirty-four Philippine woods, and a year later, the edition being exhausted, a second, revised edition was brought out. In its present form it includes a popular discussion of the qualities of woods and the meaning of timber tests, methods of testing and results of tests, structural qualities, appearance and uses. In the last-named section, in addition to common names the scientific names as far as they can be determined are given. An interesting comparison of the tests of Philippine and American woods shows that the former rank very high.

L. A. Dode's "Notes Dendrologiques" in the *Bulletin de la Société Dondrologique de France* (1907) includes notes on *Ailantus, Catalpa, Sorbus, Clerodendron* and *Platanus,* in most of which genera the author of course finds "new species"!

ANOTHER BOOK ON NORTH AMERICAN TREES

GEORGE B. SUDWORTH, dendrologist in the Forest Service, has made an important contribution to our knowledge of the trees of the western part of North America by the publication (October 1, 1908) of a thick pamphlet of 441 pages under the title "Forest Trees of the Pacific Slope." It is the first part of a work intended to deal with all the native forest trees of North America north of the Mexican boundary. This volume contains an account of the trees known to occur in Alaska, British Columbia, Washington, Oregon and California. Part II. will be devoted to the Rocky Mountain trees, part III. to the trees of the southern states, and part IV. to the trees of the northern states. The work when completed will therefore be one of the most important of those yet published by the Forest Service, and must prove of great value to students of forestry and especially of dendrology, while as a matter of course it will be indispensable to the systematic botanist. It may be asked why should the United States Forest Service incur the labor and expense of publishing a comprehensive work on the North American forest trees when we already have Sargent's "Silva" in fourteen great quarto volumes; Sargent's "Manual of the Forest Trees of North America"; and Britton's "North American Trees," but it does not require a long perusal of the book before us to convince one that it contains much that is not to be found in other books, and that it can easily justify its existence.

In the first place it is written from the dendrologist's point of view. It is rather a forester's book than one for the botanist, and so contains some things that are not to be found in other books on trees. Thus one finds under each species a paragraph relating to the longevity of the trees, another as to their particular habitat, still another in regard to the climatic conditions under which they grow, one on tolerance (of especial value to the practical forester) and one on their reproduction (also of very high value to the forester). The descriptions are non-technical and are accompanied by good life-size figures of characteristic parts, as leaves, cones, fruits, seeds and less commonly the flowers. In only a few instances was it necessary to reduce the figures below their natural size.

In the second place it is desirable that there shall be some authoritative silva for the use of the men who go into the United States Forest Service. In this book care has been taken in regard to the selection of English names for the species, and in like manner where there has been a question as to the proper scientific name one is here designated for use by the official dendrologist. In regard to this latter point it seems to the writer of this notice that on the whole a conservative course has been taken. While many trees appear here under unfamiliar names, there seems to be a good reason for every change made. There is an entire absence also of the species-making mania, and the reader soon gets the impression that the author is more interested in giving such a clear idea of the species that they may be recognized in the forests than in making out that certain observed variations are the sure indications of new species.

The definition of a tree followed by the author includes "woody plants having one well-defined stem and a more or less definitely formed crown, and attaining somewhere in

their natural or planted range a height of at least eight feet, and in diameter of not less than two inches." This definition is not, however, allowed to exclude unbranched cactuses, yuccas and palms. The uniform recapitalization of all specific names is greatly to be commended, as also the clear type (of two sizes) and the exact illustrations. Two good maps of the region covered and a good index complete this altogether admirable publication.

FUNGUS NOTES

IN a recent number of *Rhodora* (January, 1908) Dr. W. J. Farlow begins the publication of "Notes on Fungi," which promise to yield critical discussions of much value. He shows that what has been known as *Corticium tremellinum* var. *reticulatum* is in the first place not a *Corticium*, but a *Tremella*, and that the variety is a distinct species, to be known hereafter as *Tremella reticulata*. He shows that what has been known as *Synchytrium pluriannulatum* (a parasite in species of *Sanicula*) is in reality *Urophlyctis pluriannulatus*, and that a uredineous parasite of *Rubus neglectus* and *R. strigosus*, hitherto known as, or confused with, *Phragmidium gracile* is *Pucciniastrum arcticum* var. *americanum*. He is further of the opinion that the *Pucciniastrum* on *Potentilla bidentata* is *P. potentillae*. Further notes from this source will be eagerly looked for by mycologists.

In *Annales Mycologici* (V., No. 7, 1907) Professor F. L. Stevens figures and describes "Some Remarkable Nuclear Structures in *Synchytrium*." The paper is a record of facts, and the author does not attempt to base any conclusions upon what he has yet seen. Other recent fungus papers by the same author are "An Apple Rot due to Volutella" and a "List of New York Fungi" in the March and May numbers of the *Journal of Mycology* (1907), and "The Chrysanthemum Ray Blight" in the *Botanical Gazette* (October, 1907). The fungus which causes the ray blight on the chrysanthemum appears to be new and is described as *Ascochyta chrysanthemi*.

Heinrich Hasselbring's paper on "The Carbon Assimilation of Penicillium" in the *Botanical Gazette* for March, 1908, is a contribution to our knowledge of the chemistry of the assimilation of some of the simpler compounds by plants. Among the results noted is the fact that "alcohol, acetic acid and the substances from which the acetic acid radicle CH_3COO — is easily derived are assimilated by *Penicellium glaucum*."

Mention should be made here of Scott and Rorer's paper "Apple Leaf-spot caused by *Sphaeropsis malorum*" in Bulletin 121 of the Bureau of Plant Industry of the U. S. Department of Agriculture; of W. H. Lawrence's record of "Some Imported Plant Diseases of Washington," in Bulletin 83 of the Oregon Experiment Station, and Cook and Horne's "Insects and Diseases of the Orange," in Bulletin 9 of Estacion Central Agronomica de Cuba.

Here also may be mentioned Professor Harshberger's paper "A Grass-killing Slime Mould" in the *Proceedings of the American Philosophical Society*, Vol. XLV., recording a case in which the plasmodia of *Physarum cinereum* killed the blades of grass over which they had grown.

CHARLES E. BESSEY
THE UNIVERSITY OF NEBRASKA

SPECIAL ARTICLES

SOME REMARKS ON THE CULTURE OF EASTERN NEAR-ARCTIC INDIANS

DURING the past summer, 1908, the writer undertook an ethnological expedition into the James Bay region of Canada, for the Department of Anthropology of the American Museum of Natural History of New York. The original intention was to journey to Moose Factory and thence to the eastern coast of the bay, touching at Rupert's House, Eastmain River and, perhaps, Fort George, at which posts it was supposed access might possibly be had to the Naskapi Indians of Labrador, who, it was thought, might come down to these points during the summer, for the purpose of trade. On arriving at Moose Factory, it was learned that the Naskapi could not be reached *via* the west coast of Labrador, usually known

as Eastmain, and that they did not come out to any of the posts along that shore. At Nitchequon, a post situated in the Labrador interior, fifty-five days' journey from Rupert's House by canoe, and still in the hunting territory of the Northern Cree, the Naskapi are known to come in winter when driven by starvation. Otherwise they are confined to the interior of Labrador proper, held back on the east and north by the Esquimau, on the west by the Northern Cree, and on the south by the Montagnais.

As conditions were not favorable for study of the Naskapi, our attention was turned to the ethnology of the Northern Cree. The Northern, or perhaps more properly the Eastern, Cree range from Nitchequon on the north, south to the height of land around James Bay, west to the Albany River and Agomska Island. There are no Cree between this post and York, because the Northern Ojibway have worked northward to the coast and thus have separated the York Cree from the rest. So far as could be learned from the Hudson's Bay men and Indians, this has taken place within comparatively recent times, and it was also stated that the Western Cree came originally from the vicinity around James Bay, being induced to go westward by the Hudson's Bay Company. Both the York Cree and the Western Cree seem to be considered by the Eastern Cree to be somewhat different from the Eastern Cree, although admittedly the same people. Several dialects of their language are recognized by the eastern band, but the changes appear to be perfectly regular and phonetic, not affecting the grammar in any way.

The Eastern Cree claim to have always lived in the region that they now inhabit, and recognize several bands or subdivisions, known according to the locality which they inhabit. The Crees know themselves generally as Muskéko-wug, or "Swamp People." The social unit is the patriarchal family and there seems never to have been any clan organization among them. Village life is, and apparently was, unknown; for economic conditions caused single families to live by themselves, far apart from any others, and rendezvous was made every spring at some spot previously decided upon for the purpose of reuniting. At this time, the feasts, councils and meager ceremonies of these people were held. Nowadays, the hunters come to the Hudson's Bay posts every spring to trade their furs for supplies for the next year, and this coming together takes the place of the old spring meeting. Chiefs were never elected or chosen, but acquired their office through prestige by tacit consent on the death of the former incumbent. As the people rarely came together, excepting at the spring meetings, or in case of war, the chief's influence was small in comparison with that of the shaman. Shamanism, or "conjuring," as it is called in the north, is still quite extensively carried on for warlike expeditions, hunting, love-making and other purposes. Conjuring houses are still built and used. A shamanistic society, very loose in form, but apparently corresponding to the Midèwin of the Ojibway, occurs. There are but two degrees, and admission to these is through dreams. There are no initiatory ceremonies. So far as could be learned, members of this society do not attempt to cure disease. Apparently this is done by herb doctors.

The material culture of these people is now considerably debased through constant contact with the Hudson's Bay Company. Clothing in the old days was made of caribou skin, tanned without the hair in summer; in winter, of caribou skin with the hair, or of beaver and other furs. Garments were often made of twisted and woven rabbit skins. Coats with sleeves, hoods and mittens were worn by both sexes. The habitations consisted of conical or dome-shaped lodges, covered with painted skins, bark or brush. No mats were used for this or any other purpose, as articles of woven rabbit-skin seem the only fabrics made. Owing to climatic conditions, agriculture was unknown, a few berries furnishing the only vegetable food. Hunting, and, secondarily, fishing were the great resources of life. As hunting has not been checked, but rather given an impetus, by the advent of the Hudson's Bay Company, all the ancient superstitions regarding animal life may still be found in full force. Most interesting of these are a series

of observances regarding the killing of the bear. While all the eastern Algonkins have observances of this order, they seem to have become much more elaborated among the Eastern Cree.

Pottery was unknown, steatite taking its place. Semilunar knives, here used as scrapers, other knives and some arrow points were rubbed out from slate. In some parts, at least, arrow points seem to have been chipped; and in others, made of bone and antler. The grooved axe was used. Basketry, except simple vessels of birch or pine bark, was unknown. Birch bark canoes were used.

Syllabics, invented by missionaries, are now used for communication in their own language, though the Cree still employ mnemonic devices of their own invention for the same purpose. Information was obtained which seemed to show that in olden times pictorial writings on birch bark, similar to those found among the Ojibways, were known. The primitive form of art seems to have been painting, and the lines employed were geometric.

Little folk-lore was collected, and this was, in the main, typically Algonkin, but some apparently resembles the Esquimau.

A comparison of the writer's notes with Lucien M. Turner's account of "The Nenenot or 'Naskopie'" Indians,[1] and conference with Indians and white men who had been in the Naskapi country, seems to show that the culture of these people is identical with that of the old Cree. Considering the absence of agriculture, the lack of village life and clan systems, the loose social and political organization, the absence of pottery and the ordinary forms of fabrics, and the comparative difference of artifacts in general, as here noted—it may perhaps be well no longer to consider the region inhabited by the Eastern Cree and the Naskapi as belonging to the Eastern Woodland culture area, a region characterized throughout by its agricultural and village life, its comparatively highly developed social and political organization, its pottery, clothing made from skins tanned without the hair, fabrics, woven basketry, and the like. Dr. Frank G. Speck, of the Department of Archeology of the University of Pennsylvania, who spent last summer among the Montagnais of Lake St. Johns, arrived independently at the same conclusion in studying these people. It is the suggestion of the writer, then, that the culture of the region of Subarctic Eastern America inhabited by the Cree, Naskapi, and Montagnais, might better be known hereafter as the Eastern Subarctic, or Labradorean, cultural area, as it is apparently so different from the eastern woodland area with which it has hitherto been classed.

[1] Lucien M. Turner, "Ethnology of the Ungava District," Eleventh Annual Report, Bureau of Ethnology, 1889–90, pp. 167–350.

ALANSON SKINNER
AMERICAN MUSEUM OF NATURAL HISTORY

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE SECTION A—MATHEMATICS AND ASTRONOMY

COMPARATIVELY few papers on pure mathematics appeared on the program of Section A in view of the fact that the American Mathematical Society held its annual meeting in affiliation with the association. The address of the retiring vice-president, President E. O. Lovett, the Rice Institute, Houston, Texas, was read by the secretary of the section. It was entitled "The Problem of Several Bodies, Recent Progress in its Solution," and an abstract of it has appeared in a recent number of SCIENCE.

The following members of the section were elected as fellows of the association: David R. Allen, Joseph Allen, R. B. Allen, Harriet W. Bigelow, Oskar Bolza, W. H. Bussey, B. E. Carter, E. F. Chandler, Abraham Cohen, E. H. Comstock, H. A. Converse, S. A. Corey, J. A. Cragwall, F. F. Decker, C. C. Engberg, F. C. Ferry, F. E. Fowle, Philip Fox, William Gillespie, C. C. Gore, C. O. Gunther, U. S. Hanna, A. E. Haynes, Alfred Hume, W. J. Hussey, Kurt Laves, A. H. McDougall, Max Mason, Frank E. Miller, J. S. Miller, W. F. Osgood, J. M. Page, M. T. Peed, James Pierpont, S. C. Reese, W. J. Rusk, P. L. Saurel, G. T. Sellew, E. B. Skinner, A. G. Smith, D. E. Smith, P. F. Smith, Joel Stebbins, R. P. Stephens, L. B. Stewart, H. D. Thompson, E. B. Van Vleck, Oswald Veblen, H. S. White, F. S. Woods.

The sectional committee of Section A nominated the following members of the association,

who had not affiliated with any particular section, for fellowship in the association: Eugene Davenport, dean of the College of Agriculture, University of Illinois; E. K. Putnam, acting director of the Davenport Academy of Sciences; J. E. Stubbs, president of the State University of Nevada. These were also elected as fellows by the council.

In addition to the address of the vice-president, the following sixteen papers were read before the section:

1. V. M. Slipher: "The Spectrum of Mars."

2. E. B. Frost and J. A. Parkhurst: "Spectrum of Comet Morehouse."

3. E. E. Barnard: "On the Changes in the Tail of Comet Morehouse."

4. Frank Schlesinger: "The Orbit of the Algol-type Variable Delta Libræ."

5. Milton Updegraff: "The 6-inch Transit Circle of the U. S. Naval Observatory."

6. F. R. Moulton: "On Certain Implications of Possible Changes in the Form and Dimensions of the Sun, and Some Suggestions for Explaining Certain Phenomena of Variable Stars."

7. R. H. Baker: "On the Spectra of Alpha Virginis and Similar Stars."

8. F. C. Jordan: "The Orbit of Alpha Coronæ Borealis."

9. E. B. Frost: "Radial Velocities in Professor Boss's Star Stream in Taurus."

10. Philip Fox and Georgio Abetti: "The Interaction of Sun-spots."

11. Harris Hancock: "Elliptic Realms of Rationality."

12. Artemas Martin: "Algebraic Solution of the 'Three Point' Problem."

13. J. B. Webb: "Esperanto and a Sexdecimal Notation."

14. J. A. Miller and W. R. Marriott: "Comet Morehouse."

15. L. A. Bauer: "On the Interpolation Formula of Geophysics."

16. H. W. Fisk: "A Graphical Aid to the Determination of Latitude and Azimuth from Polaris Observations."

In the absence of their respective authors the paper by V. M. Slipher was read by J. A. Miller; the joint paper by E. B. Frost and J. A. Parkhurst was presented by W. S. Eichelberger; the three papers by Frank Schlesinger, R. H. Baker and F. C. Jordan, respectively, were read by J. A. Brashear; F. R. Moulton's paper was read by E. D. Roe; G. F. Hull presented the two papers by E. B. Frost and by Philip Fox and Georgio Abetti, respectively; the papers by E. E. Barnard and Artemas Martin, respectively, were read by title. The remaining papers were read by their respective authors and the abstracts which follow bear numbers corresponding to those of the titles in the list.

1. The paper by Mr. Slipher gives the results of a photographic investigation of the extreme red end of the spectrum of Mars made with special reference to water-vapor in the planet's atmosphere. It is a part of an extensive and detailed presentation which is to appear in the *Astrophysical Journal.*

2. The comet was observed photographically with a prismatic camera or with a quartz spectrograph on fifteen nights. The third and fourth carbon bands were identified, and the first, third and fourth bands of cyanogen. The plates taken with the objective prism over the six-inch Zeiss doublet show well the separate spectral images of the tail, running off the plate in most cases at a distance of over 3°. Wave-lengths were given off from unidentified bands. A brief account of the observations by E. B. Frost and J. A. Parkhurst appeared in SCIENCE, January 2, 1909.

3. Professor Barnard's paper deals with the remarkable changes in the appearance of the comet and of its tail as shown by the photographs of it, and an attempt to explain the phenomena.

There were a number of outbreaks in the comet in which volumes of matter were thrown off which could be traced for several days, on the photographs, as they receded from the comet. On one occasion the tail was violently curved and switched forward in the direction of its lateral motion. At another time the masses not only receded from the comet, but their lateral motion was also accelerated and became greater than that of the comet in the same direction. This acceleration was apparently in defiance of the laws of gravitation.

It is suggested as an explanation of these anomalous phenomena that disturbances of some kind occur in the interplanetary spaces, perhaps temporary in their nature and location, which may accelerate or retard, and bend or break the tail of a comet when they are encountered by it. It is suggested, also, that these regions of disturbance may be due to the same or a similar cause as that which produces magnetic disturbances on the earth—that is, that they are due to forces which are encountered by the comet and which have their origin in disturbances on the sun. An encounter of this kind might account for the sudden brightening of some comets, such as that of Sawerthal's in May, 1888. It might also cause the disruption of large volumes of the

cometary matter such as are shown in the photographs of Morehouse's comet on October 15, etc.

4. Sixty spectrograms of this Algol-type variable were obtained at the Allegheny Observatory during this year. These indicate a nearly circular orbit with a range of 146 kilometers per second. The center of gravity of the system is approaching us at the high rate of 46 kilometers per second. The light curves of this variable has been the subject of a recent exhaustive investigation by Kron. A study of the results obtained by him, and of the spectrographic data, enables us to infer the following with regard to the constitution of the system, upon the assumption that the light changes are caused by an eclipse. The two stars in the system have nearly equal diameters (about two and a half that of the sun), but one of them is nine times as bright as the other. Their average separation is about one thirtieth of that between the earth and the sun. If we assume that the two stars are equally dense the mass of each would be about six tenths and the density about one twenty-fifth that of the sun.

In discussing a series of measurements made two years ago upon *β Persei*, Professor Schlesinger showed that in the case of this star there is a discrepancy between the phase demanded respectively by the light and velocity changes. Further investigation has confirmed the reality of this discrepancy and has shown that it can not be accounted for by any uncertainties in either the photometric or spectrographic data. It is interesting to notice that the same discrepancy is present in the orbit of *δ Libræ*. In this case the light phase lags more than two hours behind the velocity phase. The discrepancy is, therefore, somewhat greater than in the case of *β Persei*, but it is in the same direction.

5. Professor Updegraff gave the following account of the six-inch transit circle of the U. S. Naval Observatory:

This instrument was acquired by the Naval Observatory with a view to its employment in doing fundamental work. The nine-inch brass transit circle made by Pistor and Martins, of Berlin, and mounted in the old Naval Observatory in 1865 was considered unsuitable for fundamental work of the highest class, and after the removal of the observatory to the new site on Georgetown Heights about the year 1893, the new six-inch steel transit circle was designed by Professor Wm. Harkness and was built by the well-known instrument makers, Warner & Swasey, of Cleveland, Ohio. The instrument was mounted in the west transit circle house at the new Naval Observatory in December, 1897, and was first brought into use in June, 1899. A description of the six-inch transit circle may be found in volume III., Part 4, of the *Publications* of the Naval Observatory, together with an account of the work done with it up to March, 1901.

The design of the instrument is substantially the same as that of the later Repsold meridian circles, and certain features have been the subject of considerable controversy. It was, I think, the first large instrument of this kind to be built of steel, which being a much stiffer metal than brass is expected to diminish errors due to flexures. This feature has been much criticized, but the example set by Professor Harkness has been followed by the Repsolds in making the new transit circle for the observatory at Kiel, Germany, which is also of steel, and the prospect is that steel or some other rigid metal will finally be recognized as preferable to brass for the construction of large instruments of this kind.

When brought into use the new instrument was found to have various defects, the most important of which, an extraordinary variability in azimuth, was found to be intimately connected with temperature. After a very troublesome investigation this was found to be due to two causes. The cast-steel bed plates which supported the instrument were, through non-homogeneity of the metal, distorted by temperature changes, and the marble piers of the instrument were not properly supported on their foundations. New bed plates of cast iron were provided, and the marble piers of the instrument were replaced by brick piers. These measures gave relief, and rendered the instrument remarkably stable in azimuth.

A peculiar but not serious difficulty has arisen from the construction of the tube of the telescope of steel. In a brass telescope of moderate size the changes in focal length of the object glass with temperature is nearly the same as the expansion and contraction of the tube with changes of temperature. But the coefficient of expansion of steel is smaller than that of brass, and in the case of the tube of the six-inch transit circle is not sufficient to make up for the change of focus of the object-glass. This makes necessary a change of stellar focus from winter to summer and vice versa.

In the fall of 1901 the instrument had been put in good condition, and for about one year following was employed in observations of the fixed stars and also in observations of the sun, moon and planets. The latter work with the instrument was continued up to September, 1903, when work

was discontinued, and practically no observations have been made with it since that time. In 1906 a transit micrometer made by Warner & Swasey was substituted for the old eye-end and a few practise observations were made by various observers.

The plan for the future work of the instrument is given in a general way in the report of the superintendent of the U. S. Naval Observatory for the fiscal year ending June 30, 1908, which has just been issued. This plan involves an attempt to render the observations of the sun and fixed stars and, consequently, of all bodies which are referred to them, of as strictly fundamental a character as is practicable.

The importance of such work to the science of astronomy and in the plan of work of an observatory maintained by the government is generally recognized by astronomers. It is expensive and laborious and in some respects perhaps less attractive than some other kinds of astronomical work in that it can not excite the interest or occupy the attention of the general public to any great extent. But for its proper performance, technical qualifications of a high order are required. Partly for these reasons, no doubt, this work has, with a few notable exceptions, not been as efficiently done in the observatories of the world generally for many years as is needed for the advancement of astronomy.

All accurate observations of the positions of the planets depend on this work and it thus becomes in some degree necessary for the further advancement of celestial mechanics. It is equally important for the solution of that greatest problem of physical science, the constitution of the visible universe, which must perhaps wait on further lapse of time and increase in accuracy of the observations of the places of the stars.

The late Professor Asaph Hall, U.S.N., was much interested in this kind of astronomical work, as may be seen by consulting the *Ast. Nach.*, No. 1692.

6. The problems treated in the paper by Professor Moulton are: (1) The theoretical shape of the sun, (2) the character and period of its possible gravitational oscillations, (3) the effects of changes of its dimensions upon its rate of rotation, (4) its energy of rotation, (5) its potential energy, (6) its temperature and rate of rotation and (7) applications of the same ideas to variable stars.

The results are: (1) the sun is oblate and the theoretical difference in its polar and equatorial diameters is less than 0″.01. (2) Its gravitational oscillations are expressible in spherical harmonics whose periods depend upon their order. Assuming the sun to be a homogeneous liquid, the longest period is 3 h. 8 m. If it has the viscosity of water this oscillation will change to 37 per cent. of its value in 2.2×10^{18} years. (3) The change of the sun's diameter by 0″.1 will change its period of rotation by 7.8 minutes. (4) The formula was found for the change in the rotational energy. (5) The formula for the potential of spheroid of polar radius c, equatorial $c\sqrt{1+\lambda^2}$, and mass m upon itself is

$$V = \tfrac{3}{5}k^2 \cdot m^2/c(1 - \tfrac{1}{3}\lambda^2 - \tfrac{7}{15}\lambda^4 \cdots).$$

(6) The expansion of the sun by 0″.1 will decrease its temperature (assuming its specific heat is unity) more than 1,400° C., and if it obeys Stefan's law, diminish its radiation (assuming its temperature to be 6,000° before expansion) by more than 65 per cent. (7) It is shown how gravitational oscillations can explain many puzzling phenomena of variable stars, such as variable periods in the so-called eclipse variables, secondary maxima and minima, varying maxima and minima, etc. It is thought that these factors are supplementary even in those cases where the binary character of the star is certain, and that perhaps in certain classes of stars they may be the only causes of variability.

7. Spectroscopic binaries of the helium type may be divided for convenience into two classes: those of long period and high eccentricity, and secondly, those whose periods are short and whose orbits are nearly circular. Mr. Baker's paper relates to the latter and much more numerous class, of which α *Virginis* is typical. This class includes a large number of Algol variables, as a special case where the orbital inclination approaches 90°, if the eclipse theory of their light variation be assumed. The following conclusions were reached: The majority of spectroscopic binaries of the helium type belong to one class, they revolve in close proximity in nearly circular orbits of short period, they are Algol variables inclined at various angles, the spectra of both components are, in general, visible and similar, and the fainter components are less massive than the brighter ones.

8. The binary character of α *Coronæ Borealis* ($\alpha = 15^h\ 30^m$, $\delta = +27°\ 3'$) was discovered by Hartmann from six plates obtained at Potsdam in 1902 and 1903. The spectrum is of the type 1 a 2 in the Vogel classification.

One hundred and thirty-seven plates of this star were obtained at Allegheny Observatory between

April 2, 1907, and September 11, 1908. The emulsions used were Seed 27, Seed 23 and lantern slide. The lines K, Hδ, Hγ, λ 4481 and Hβ were the only ones measured. On the lantern slide and Seed 23 plates numerous other faint lines were visible, and in some cases measurable, but were not used. Among them are the lines λ 4128 (silicon), λ 4227 (calcium), λ 4233 (iron), λ 4352 (magnesium), λ 4472 (helium), λ 4550 (iron). A dozen other lines could be approximately located, while still others were occasionally faintly visible.

Mr. Jordan found that the total range in velocity is 69.86 km. As the periastron point is in the fourth quadrant, the ascending branch of the velocity curve is steeper than the descending. The center of gravity of the system has practically no velocity in the line of sight.

No trace of a secondary spectrum can be seen.

9. In No. 604 of the *Astronomical Journal*, published on September 25, 1908, Professor Lewis Boss communicated an important paper entitled "Convergent of a Moving Cluster in Taurus." In this he presents the evidence, derived from their proper motions, that 39 stars in or near the *Hyades* are converging upon the same point. Radial velocities have been published by Küstner for three stars of the cluster, namely, γ, δ and ε *Tauri*. Assuming these values to be representative of the cluster, the radial velocities of the remaining stars can be inferred. They would range from 37 to 44 km. per second. Before the article was printed Professor Boss had privately called the attention of Professor Frost to his results and to the desirability, in so far as possible, of determining the radial velocities of the stars in the cluster. He accordingly added the 41 stars to the observing program of the spectrograph, and during the present autumn they have been observed, as circumstances permitted, chiefly by Messrs. Barrett and Lee.

The spectra of most of the stars are of the first type, so that the lines are generally diffuse and suitable for only the dispersion of the single prism which has been regularly employed for them.

There has not yet been opportunity to measure these plates and this note is merely given to state that this piece of work is in progress. Thus far 60 spectrograms have been obtained of 21 of the stars, the magnitude of which are mostly between 4.5 and 5.6.

It may be said from a preliminary examination of the plates that no star contradicts in sense the value presumptive from Professor Boss's researches, and in general the radial velocity appears to be of about the amount expected. Some of the spectra will hardly admit of accurate enough measurement to establish the accordance with the predicted values. This examination only indicates that the stars thus far observed are receding from the sun with velocities of about 40 km. per second. No inference can yet be reached as to the differences in radial velocity dependent upon the star's position in relation to the point of convergence.

We have been somewhat surprised at the large proportion of spectroscopic binaries already detected in this cluster. Six of those so far observed appear to be certainly of this character, and others are suspected.

The six are: *90 Tauri* and B.D. 15°.637, found by Mr. Barrett; *64 Tauri* and *97 Tauri*, found by Mr. Lee; θ^2 *Tauri* and *69* (Upsilon) *Tauri*, found by the writer. The last two had been observed before Professor Boss called attention to the cluster. θ^2 *Tauri* has also been detected as a spectroscopic binary at the Lick Observatory. Double lines are exhibited by the first two and last three stars.

10. The paper by Messrs. Fox and Abetti presents evidence proving occasional interaction of sun-spots. On spectroheliograms obtained on September 10, 1908, regions surrounding three spot groups then just past the central meridian were observed to burst synchronously into active eruption. The eruptions progressed until the interval between the two larger groups, about 120,000 miles, was completely and brilliantly bridged. The whole display lasted less than four hours. Successive plates, shown by lantern slides, revealed the progressive stages of the demonstration.

11. It is known that on the Riemann surface associated with

$$s = \pm \sqrt{A(z-a_1)(z-a_2)(z-a_3)(z-a_4)},$$

in which a_1 and a_2 are connected by a canal as are also a_3 and a_4, that every one-valued function of position which has everywhere a definite value is of the form

$$w = p + q \cdot s,$$

where p and q are rational functions of the complex variable z; and reciprocally every function of the form

$$w = p + q - s$$

is a one-valued function of position on this Riemann surface. If we denote two such functions by

$$w_1 = p_1 + q_1 \cdot s, \quad w_2 = p_2 + q_2 \cdot s,$$

then the sum, difference, product and quotient of the two functions w_1 and w_2 are functions of the form

$$w = p + q \cdot s.$$

Let z take all real and complex values and consider the collectivity of all rational functions of z with arbitrary constant real or complex coefficients. These functions form a closed realm, the individual functions of which repeat themselves through the processes of addition, subtraction, multiplication and division, since clearly the sum, the difference, the product and the quotient of two or more rational functions is a rational function and consequently an individual of the realm. This realm is denoted by (z).

It is evident that if we add (or *adjoin*) the algebraic quantity s to this realm we will have another realm, the individual functions or elements of which repeat themselves through the processes of addition, subtraction, multiplication and division. This realm includes the former realm. We shall call it the elliptic realm and denote it by (s, z).

Owing to a theorem due to Liouville, the most general one-valued doubly periodic function is a rational function of z and s. It is consequently a one-valued function of position in the Riemann surface and belongs to the elliptic realm of rationality (z, s).

The elliptic or doubly periodic realm of rationality (z, s), where

$$s = \pm \sqrt{A(z-a_1)(z-a_2)(z-a_3)(z-a_4)}$$

degenerates into the simply periodic realm when any pair of branch-points are equal, say $a_1 = a_2$; and into the realm of rational functions when two pairs of branch points are equal, say $a_1 = a_2$ and $a_3 = a_4$.

Thus the elliptic realm includes the three classes of one-valued functions: (1) the rational functions, (2) the simply periodic functions, (3) the doubly periodic functions. All these one-valued functions, and only these, have algebraic addition-theorems.

In other words, *all functions of the realm (z, s) have algebraic addition-theorems, and no one-valued function that does not belong to this realm has an algebraic addition-theorem.*

We have thus the theorem: The one-valued functions of position on the Riemann surface

$$s^2 = A(z-a_1)(z-a_2)(z-a_3)(z-a_4)$$

belong to the closed realm (z, s) and all elements of this realm and no others have algebraic addition-theorems.

Professor Hancock's paper will be offered to the *American Journal of Mathematics* for publication.

12. The paper by Artemas Martin is devoted to an algebraic determination of the point within a triangle at which the sides subtend given angles. The paper is to appear in the *Mathematical Magazine*, which is edited by the author of this paper.

13. The paper by J. Burkitt Webb is devoted to exhibiting the advantages which would result from the adoption of a system of notation with 16 as its base. The success which has attended the movements towards a universal language has inspired the author with hope in the success of a movement towards the selection of a more useful system of notation, and he pointed out the many advantages which the base 16 would offer.

14. This paper is devoted to a discussion of a series of photographs of comet Morehouse, made at Swarthmore College by J. A. Miller and W. R. Marriott from October 2 to December 3, 1908. The comet was photographed from one to three times every clear night within that period. These photographs show remarkable and, in some instances, rapid changes in the form of the comet's tail and in the arrangement of the streamers. The most striking changes occurred on October 4; on October 15, 16, 17, 30, 31 and November 1 the changes were sufficiently rapid to enable one to measure an increase of the distance of a condensation in the tail upon photographs taken less than two hours apart.

15. The rather prevalent custom of resolving or expressing every natural phenomenon—be it periodic or otherwise—by a Bessel or a Fourier series or by spherical harmonic functions, has brought about at times, especially in geophysical and cosmical phenomena, if not direct misapplications, at least misinterpretations of the meaning and value of the derived coefficients. Instead of clarifying the situation our calculations may have actually contributed to befog it. Instead of rejecting, one must learn to consider the outstanding residuals as the *true* facts of nature and not treat them as though they were "abnormal" or contrary to nature's law.

Dr. Bauer exemplified these statements in a brief discussion of two cases that are typical in geophysical investigations—the one involving an application of spherical harmonic functions to the representation of the distribution of the earth's magnetism over the earth, while the other involved the use of Fourier series in the representation of certain diurnal geophysical phenomena.

The chief purpose of the paper was to recall

renewed attention to the limitations, from a physical standpoint, of the form of "interpolation formulæ" usually employed in the representation of natural phenomena.

16. Mr. H. W. Fisk considers the formula for latitude,

$$\phi = h - p \cos t + \tfrac{1}{2} p^2 \sin 1' \sin^2 t \tan h,$$

from Chauvenet's I., § 176, and the formula for azimuth,

$$A = p \sin t \sec \phi + p^2 \cos \phi \tan \phi \sin t \cos t \sin 1',$$

from Jordan, "Zeit und Orts-Bestimmung," p. 122. The first terms of these formulas are readily computed. The last terms, called correction terms, are arranged as a set of curves from which the value is quickly taken by inspection. The geographical limits within which this method may be used, as well as the expected accuracy under different conditions are discussed. Attention is given to the change in correction terms due to the progressive change in the value of p.

The general committee elected Professor E. W. Brown, Yale University, vice-president and chairman of the section. Professor G. A. Miller, University of Illinois, continues in office as secretary. The section elected Professor G. B. Halsted, councilor; Professor Winslow Upton, Ladd Observatory, as member of the sectional committee for five years.

G. A. Miller,
Secretary of Section
University of Illinois

SOCIETIES AND ACADEMIES

THE WASHINGTON ACADEMY OF SCIENCES

The fifty-first meeting of the Washington Academy of Sciences was held at Hubbard Memorial Hall, January 5, 1909. Dr. L. O. Howard presided.

Dr. E. B. Poulton, F.R.S., Hope professor of zoology in the University of Oxford, delivered an address on "Recent Researches on Mimicry and Seasonal Forms of Butterflies," of which he has kindly furnished the following abstract:

The lecturer explained the theory of mimicry proposed by H. W. Bates, showing in illustration some of the figures from the plates of the original monograph read before the Linnean Society of London, November 21, 1861. In these, as in most of Bates's examples, Pierine butterflies, presumed to be palatable to enemies, were seen mimicking the unpalatable Ithomiine (Heliconine) butterflies from the same localities. Succeeding illustrations exhibited oriental Pierine butterflies of the genus *Delias* acting as models instead of mimics, and beautifully resembled by moths of the subfamily Chalcosiinæ (Zygænidæ)—themselves admitted to belong to a group defended by its unpalatability. Such examples are of course inexplicable by the theory of Bates, but receive an interpretation on the hypothesis of Fritz Mueller, which supposes that the resemblance between distasteful forms has been gained in consequence of the saving of life effected by a lessened amount of experimental tasting by enemies. That the same Muellerian principle holds in other groups is seen in the numerous and varied distasteful forms which mimic the African Lycid beetles and by resemblances between well-defined wasps of different groups in the same locality.

The alternative between a Batesian and Muellerian interpretation may be approached from another point of view. In the case of a distasteful butterfly invading a new country we may enquire whether the indigenous species influenced by it are well concealed and presumably palatable, or conspicuous and presumably distasteful. The two large Danainæ of North America are especially interesting from this point of view. Formerly placed by Moore in two genera peculiar to the new world, *Anosia* and *Tasitia*, recent examination has shown that they are congeneric with each other and with the more dominant old world *Salatura* and *Limnas*. All four genera certainly sink to *Danaida*. The old world forms are more numerous and are far more extensively mimicked than those of the new. They, furthermore, enter into mimetic relations with other *Danainæ*. The American species of *Danaida*, on the other hand, are only mimicked by a single Nymphaline species in the north. They extend through South America beyond the southern tropic without entering into any relationship with the indigenous butterfly fauna, except the possible incipient mimicry of a form of *D. plexippus* by an *Actinote*, one of the Acræinæ. It may be inferred from these facts that *Danaida* is an old world Danaine genus which has reached the new world in comparatively recent times and has entered South America by way of North America.

The well-known mimic of *D. plexippus*, *Basilarchia* (*Limenitis*) *archippus* has been evolved from *B.* (*L.*) *arthemis*—with a pattern of the *Limenitis* type found through the temperate circumpolar belt. In the theory of the production of mimetic resemblance by climatic or other local influences the invading Danaine should have been influenced to produce a *Limenitis* pattern in the northern temperate zone. It should have been the mimic instead of the model. The black and white

pattern and conspicuous surface of the form (*B. arthemis*) which has been influenced supports strongly the Muellerian hypothesis. The mimic has in fact exchanged its original conspicuous pattern similar to that of the invading Danaine. *Danaida berenice* of Florida is probably a later invader than *plexippus* and has modified into resemblance with itself the mimic already formed under the influence of this last-named Danaine. But the change is so recent that distant traces of the original mimicry of *plexippus* are easily seen in the *floridensis* (= *eros*) form of *archippus*.

Evidence in favor of the Muellerian hypothesis is also to be found in the complex group of mimetic butterflies which are ranged round the North American *Papilio* (*Pharmacophagus*) *philenor*. The female of *Papilio asterius*, a female form of *P. glaucus* (= *turnus*), and both male and female of *P. troilus* form primary mimics of *philenor*, but also appear to exhibit an evident secondary approach towards one another. *Basilarchia* (*Limenitis*) *astyanax*, considered by Haase as a mimic of *philenor*, is rather to be interpreted as a secondary mimic of the three mimetic swallow-tails. The female of *Argynnis* (*Semnopsyche*) *diana*, also thought by Haase to be a mimic of *philenor*, certainly resembles *B.* (*L.*) *astyanax*, as was clearly stated by Scudder. It is therefore a tertiary mimic. These complex resemblances to mimics and even to mimics of mimics rather than to the central model, are intelligible on the hypothesis of Fritz Mueller and not on that of H. W. Bates.

The concluding section of the address dealt with recent additions to our knowledge of the complex phenomena of mimicry in the females of the African *Papilio dardanus* (= *merope*), and with seasonal changes in African Nymphaline butterflies. A representation of a family of 28 individuals bred from the eggs laid by a *hippocoon* female of the South African *P. dardanus cenea* was thrown upon the screen. The family consisted of 14 non-mimetic males, 3 *hippocoon* females, like the parent, mimicking the Danaine *Amauris niavius dominicanus;* 3 *trophonius* females, mimicking *Danaida chrysippus;* and 8 *cenea* females, in part mimicking *Amauris albimaculata* and in part *Amauris echeria*. The recently described *flammoides* female form of the tropical subspecies of *dardanus*, extending from Nairobi westward to the Atlantic, was also represented. This is the only form which resembles a model other than a Danaine—the Acræine *Plancina foggei*. The evolution of the mimetic forms of *dardanus* from a non-mimetic female like that of the Abyssinian *P. antinorii* or the Madagascar *P. meriones* was shown to be readily intelligible through the intermediate form *trimeni* from the Kitnya escarpment.

In addition to the seasonal forms of the African species of *Precis*—*sesamus, antilope, actia, archesia* and *artaxia*, the recent evidence that similar changes may occur in the genus *Charaxes* was described and illustrated on the screen. A family of individuals bred from eggs laid by *Charaxes neanthes* contained one specimen of *C. zoolina*. This fact confirmed and placed beyond controversy the evidence that had long been accumulating that these are but forms of a single species.

This interesting and conclusive evidence has been obtained at Durban, Natal, by Mr. G. F. Leigh, who also bred the large family of *P. dardanus*, already referred to. The conclusions as to the seasonal forms of *Precis* are founded on the specimens bred by Mr. Guy A. K. Marshall at Salisbury, Mashonaland.

J. S. DILLER,
Recording Secretary

THE BOTANICAL SOCIETY OF WASHINGTON

THE 50th regular meeting of the society was held on November 21, 1908, Vice-president Thos. H. Kearney presiding. The following papers were read:

Plant Breeding in England and Sweden: Dr. ALBERT MANN.

Dr. Mann's paper, which was illustrated by a number of excellent lantern slides, treated chiefly of the methods of culture of barley, as observed by him during a recent trip to England and Sweden. In England he visited Mr. Beaven, of Warminster; Professor Biffen, of Cambridge, and John Garton, of Warrington. His observations showed that English barley culture is carried to much higher perfection than in the United States; that two-row barley, except in yield, is generally preferred; and that pedigree stock is the only source of permanent grain improvement. At Svalof, Sweden, an ingenious system of classification and original methods of breeding have produced remarkable results. The two chief ideas of Svalof, namely, the securing of new varieties by selection from old land races and the production of pure pedigree stock by growing such from a single mother plant were fully discussed and in general heartily commended. Information of minor importance was secured from Professor de Vries, of Amsterdam; Professor Johannsen, of Copenhagen; Professor von Tschermak, of Vienna,

and Professor Kraus, of Munich. The relative lack of information in the United States as to work done by European barley-growers was in strong contrast to the accurate data possessed by them in regard to work in this country. Mr. E. S. Beaven, of Warminster, not only knew definitely the quality and yield of all our American barleys, but he also had samples of every variety from every section of this country. This spirit of progressiveness is deserving of our attention. Mr. Beaven spoke highly of our California brewing barley, but he had a less favorable opinion of our other grades, especially of some now grown in the northwest.

The use of Timbe Barks by the Mexicans in the preparation of Alcoholic Drinks: W. E. SAFFORD.

Timbe, or timbre, is a name applied to certain barks and roots offered for sale in the markets of San Luis Potosí and several other Mexican cities for use in the manufacture of pulque. They have a bitter astringent taste and evidently abound in tannic acid. On the Pacific coast of tropical Mexico the same name is applied to certain barks used in tanning leather. The identity of the principal timbes has not hitherto been established and the part they play in the manufacture of pulque has not been understood. Among the most important plants from which they are obtained are *Acacia filicioides*, the principal source of the San Luis Potosí supply, and a sumach, *Rhus pachyrrachis*. Other barks used for a similar purpose are those of *Calliandra grandiflora* and *Calliandra Houstoni*, the latter of which is also used extensively by the Mexicans as a cure for intermittent fever, under the name of pambotano. At first the sap of the agave from which pulque is made is sweet and clear. It is sold about the streets in this condition under the name of *aguamiel* (honey-water). It soon begins to ferment spontaneously and becomes milky and finally stringy, acquiring a putrid smell, if unchecked, from the fermentation caused by the lactic-acid bacteria contained in it. The timbe bark, after having been toasted and pounded, is added to the sap about four hours after the fermentation has begun. It has the effect of precipitating the greater portion of mucilaginous substances held in solution, undoubtedly owing to the action of the tannic acid in the bark upon the proteids, which, if let alone, would cause the liquid to putrify or turn sour. Its action, then, may be compared to that of hops in the manufacture of beer, which probably do not destroy the lactic bacteria, but cause the precipitation of albuminous material. In addition to this the timbe imparts a pleasant bitter taste to the drink.

W. E. SAFFORD,
Corresponding Secretary

THE TORREY BOTANICAL CLUB

THE meeting of November 25, 1908, was called to order at the museum building of the New York Botanical Garden at 3:40 P.M., with Dr. M. A. Howe in the chair. Fourteen persons were present. The minutes of the meeting of November 10 were read and approved.

The resignation of Dr. Valery Havard, dated November 8, 1908, was read. A motion was made and carried that the resignation of Dr. Havard be accepted and that his name be transferred to the list of corresponding members.

There was no announced scientific program for this meeting, but the following communications were made:

Dr. Britton showed fruits of the rare and local tree, *Prioria copaifera* Griseb., which he collected, in company with Mr. William Harris, at Bachelor's Hall, Jamaica, near where it was originally discovered sixty years ago by Nathaniel Wilson, who sent it to Grisebach. *Prioria* is one of the largest trees of Jamaica, sometimes attaining a height of ninety feet, and is a member of the senna family. So far as is known, this tree is found only on two estates in Jamaica, and grows at an elevation of from five to six hundred feet. This species is characterized by having a one-seeded legume, which is indehiscent. The genus *Prioria* is reported to be represented also in the Republic of Panama.

Dr. Murrill displayed photographs and colored drawings of several of the larger local fungi. He also explained reproduction of colored drawings by the four-color process. This process seems to be the most satisfactory for representing fungi in colors.

Mr. Nash exhibited a living plant of *Dendrobium Cœlogyne*, a rare orchid from Burma, which has just flowered in the conservatories of the New York Botanical Garden. Specimens of *Cœlogyne* and of other species of *Dendrobium* were also shown to illustrate the characters of these two genera. While the flowers of *Dendrobium Cœlogyne* resemble those of a *Dendrobium*, the habit is that of a *Cœlogyne*.

PERCY WILSON,
Secretary